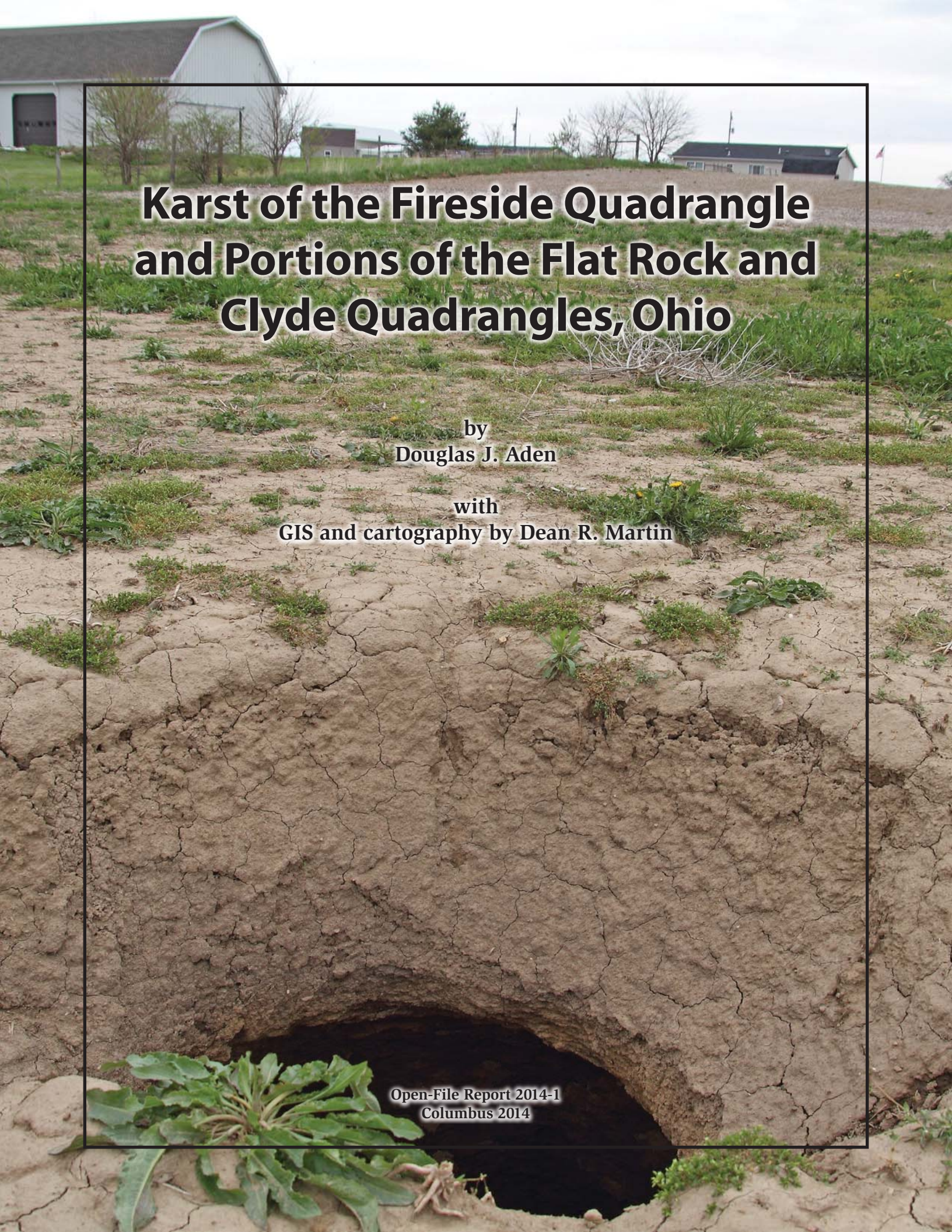

Karst of the Fireside Quadrangle and Portions of the Flat Rock and Clyde Quadrangles, Ohio

by
Douglas J. Aden

with
GIS and cartography by Dean R. Martin

Open-File Report 2014-1
Columbus 2014

DISCLAIMER

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Cover image: With a diameter varying from 2 ft at the bottom lip of the surface cone to 3 ft below the overhanging rim, this 4-ft deep sinkhole in Seneca County has an unusual eastward plunging shape that widens in the subsurface. Formed in glacial till above the Devonian-age Delaware limestone, there are 15 active sinkholes within 250 ft of this feature. Three houses and a barn sit within 500 ft of this sinkhole. View is east-northeast and Seneca Caverns is about one mile north.

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Introduction

Karst terrain forms by dissolution of carbonate rocks, such as limestone or dolomite, or evaporites, such as gypsum or salt, and is characterized by features including sinkholes, disappearing streams, caves, and springs. *Sinkholes* (or *sinks*) are enclosed depressions that do not usually hold water; they often have a "throat" or opening at the bottom where they drain to the subsurface. When a stream flows into a sinkhole, it is known as a *disappearing stream* or *losing stream*. Water flowing into the ground can cause solution enlargement of natural fractures in the rock and eventually can grow into caves. In Ohio, a *cave* is defined as "…a naturally occurring void, cavity, recess, or system of interconnecting passages beneath the surface of the earth or within a cliff or ledge…" (State of Ohio, 1989).

The many passageways formed in karst terrain allow for high connectivity between the land surface and the water table. These passageways permit water to bypass soil and rock layers that filter out contaminants. Consequently, when compounds such as fertilizers, pesticides, and waste enter sinkholes, they are rapidly transported to the water table and quickly pollute water wells, streams, and rivers. When water exits these solutional features, a *spring* is formed. Such springs enable release of these contaminants at the surface.

The different types of karst features may pose infrastructure complications; roads, utilities, houses, and other facilities built in karst areas are at risk of subsidence, collapse, or other damage. In order to provide a reference for future planning on both the local and regional scale, the Ohio Geological Survey has produced this map book identifying the known and suspected karst areas in the vicinity of Bellevue, Ohio, including portions of Erie, Huron, Sandusky, and Seneca Counties.

Previous Work

Karst areas have been studied in Ohio for many years. In the 1980s and 1990s, karst was researched for the proposed Superconducting Super Collider and was mapped statewide to determine areas suitable for storage of low-level nuclear byproducts. Ohio's preliminary map of karst features (Pavey and others, 1999) was completed in 1997 and released in 1999; it since has been updated with new data in 2003, 2005, and 2007 and will be updated again in the near future.

In the spring of 2008, severe karst-related flooding occurred in Bellevue and initiated increased concern regarding Ohio's geohazards (Raab and others, 2009; Pavey and others, 2012). From 2011 to 2012, karst was mapped in the Delaware County region (Aden and others, 2011) and in the Springfield and Donnelsville 7.5-minute quadrangles (Aden, 2012). Next, from fall 2012 to spring 2013 karst was mapped in the Bellevue 7.5-minute quadrangle and parts of the Clyde and Castalia quadrangles (Aden, 2013). Finally, mapping was completed near Bellevue, Ohio, from fall 2013 to spring 2014 in the Fireside and Flat Rock 7.5-minute quadrangles and the remaining portion of the Clyde quadrangle.

Methodology

A digital elevation map (DEM), generated from LiDAR (Light Detection and Ranging) data, was used to create a map layer that identified low, enclosed areas. To locate potential sinkholes, these low spots were cross referenced with known karst points, bedrock geology, aerial photography of multiple sources and ages, soil maps, glacial drift thickness maps, and water well logs. Suspect locations were then visited in the field, evaluated, and photographed. Through this process some of the LiDAR returns were found not to be sinkholes; features such as building foundations, broken field tiles, steep-walled streams, road culverts, and glacial features often produced enclosed areas similar in shape to sinkholes. Many of these misleading features were eliminated remotely using both 6-inches-per-pixel aerial photography and experience from past field verification. However, many points remained that

could not be distinguished remotely and these were visited in the field.

Results

The resulting karst feature data set was overlain on four different geologic data sets—the Land Surface, the Bedrock Geology, the Bedrock Topography, and the Drift Thickness maps—to show how the features are related to the local geology. The first of these is the Land Surface map (p. 5), which shows the 87 two-km^2 tiles and the 7.5-minute quadrangles that form the project area overlain on the DEM of the land surface. The Fireside quadrangle was the core project area. However, some adjacent points were mapped to edge match last year's project, particularly in Flat Rock and Clyde quadrangles. The Land Surface map shows that south of Bellevue, sinks are concentrated near the Fireside and Flat Rock quadrangle boundary and trend south–west to north–east.

On the Land Surface map, tiles outlined in red contain the karst features identified through this project. No karst was identified in black-outline tiles. In total, there are 975 karst features, including 1 spring, in 87 tiles. On the top left of each aerial imagery page (p. 9–50) is a Tile Number that references the corresponding numbered tile on the four overlay maps.

There are four types of karst features identified on each map:

- Red circles indicate field-verified features, i.e., those that have been visited in the field and confirmed as karst.
- Orange circles indicate sites that were visited but could not be verified at the time, for example a suspicious depression that is flooded or that lacks an active sink throat and cannot be clearly classified.
- Yellow circles represent areas with suspect characteristics, such as a subtle LiDAR depression, a location where access to the property could not be gained, or where there was not enough time to field check the point.
- Blue squares represent springs, where water was found flowing from the subsurface.

The next overlay map is the Bedrock Geology map (p. 6). This map shows that the karst features are forming primarily by dissolution of the Columbus Limestone; however, it is thought that the Salina undifferentiated below is also affecting the sinks. The Salina contains beds of the mineral anhydrite, which alters to gypsum by hydration. This change causes swelling of about 40 percent (Boggs, 2006), which could help to fracture surrounding rocks; but more importantly, gypsum is easily dissolved by additional ground water, removing roof support and leading to collapse. In the Bellevue region, there are two main ways that karst is expressed: one where catastrophic collapse forms a steep-walled, cone-shaped depression with active sinking and a second that is much more broad and shallow and may or may not have an active sink throat where water is draining into it. It should be noted that there are karst points on 'shale' according to this map; this means one of two things. Either the shale is very thin and the sinks are forming through it or the bedrock map needs to be refined.

Six hundred and eighty seven (687) of the 975 karst features are within the Columbus Limestone (**Dc** on the Bedrock Geology map) and 111 are within the Delaware Limestone (**Dd**). Regarding the shale there are 152 points within the Olentangy and Plumbrook shales (**Dol** and **Dolpb**). The majority of the remaining features in the Bass Islands Dolomite or Salina undifferentiated (within the **Sbi** or **Ssu**). These formations and the others on the Bedrock Geology map are buried in many places by surficial glacial materials. The elevation of the bedrock below the surficial materials is called Bedrock Topography and is shown on page 7. The elevations of the bedrock surface were subtracted from the DEM (p. 5) to create the Drift Thickness map (p. 8). Knowing the drift thickness is useful because where the drift is shallow—about 25 ft or less—sinkholes are commonly expressed. Other sinkholes may exist but were either buried beneath the glacial drift or prevented from forming by thick drift. The Drift Thickness map clearly shows that in the Bellevue area the sinkholes are concentrated along areas of thin glacial drift.

Following the four overlay maps are the detailed two-km2 map tiles (p. 9–50) that contain specific karst feature locations. Also included on these maps are karst depressions represented by yellow to red topographic lines. Each concentric ring represents a one foot drop in elevation toward the low point of an internally drained area.

Conclusions

Of the 975 mapped karst features, 468 have photos

(from multiple angles for interesting features) and 834 appear on LiDAR. Very few springs were located in this area—reemergence is almost exclusively to the north in the direction of subterranean drainage. Furthermore, springs do not typically show up as depressions unless a catch basin was built and subsequently failed or a build-up of material deposits from carbonate-rich spring waters forms a mound. The large number of sinks found without LiDAR attests to the need for spending time in the field near known karst areas, looking for new features and talking to the public. Farmers and other land holders are still some of the best sources of local information, particularly for historical features, such as drained ponds, old mill races, and even sinkholes that have been periodically filled in.

In addition to this map book, a DVD containing the GIS data, metadata, LiDAR depressions, and photographs of many of the features is available. The GIS data contains details such as the location of each point and a brief description of what was found there. The metadata provides information on the sources and quality of the data used in this project. The LiDAR depressions layer records the depths and areas for many of the sinkholes. In addition, the collection of photographs captured for many of these features can be used to monitor the growth of preexisting sinkholes and development of new karst features, as well as assisting in identification. Identification is important because karst regions are highly susceptible to pollution and structures built near them may subside. Furthermore, in the Bellevue region, low-lying karst features may be subject to flooding during periods of unusually high precipitation when the water table rises above the land surface. The maps in this report will allow areas of land development near karst features to be better planned and maintained.

Acknowledgments

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References Cited

Aden, D.J., 2013, Karst of the Bellevue Quadrangle and portions of the Clyde and Castalia Quadrangles, Ohio: Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2013-1, 4 p., 59 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2013-1.pdf > .

Aden, D.J., 2012, Karst of Springfield, Ohio: Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2012-2, 3 p., 25 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2012-2.pdf > .

Aden, D.J., Powers, D.M., Pavey, R.R., Jones, D.M., Martin, D.R., Shrake, D.L., and Angle, M.P., 2011, Karst of the western Delaware County, Ohio, region: Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2011-4, 2 p., 35 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2011-4.pdf > .

Boggs, Sam, Jr., 2006, Principles of sedimentology and stratigraphy (4th ed.): Upper Saddle River, NJ, Pearson Prentice Hall, p.199.

State of Ohio, 1989, Ohio Revised Code 1517.21 Cave definitions, *in* chap. 1517 *of* Title 15 Conservation of Natural Resources: State of Ohio, Ohio Revised Code, accessible at < http://codes.ohio.gov/orc/1517.21 > .

Pavey, R.R., Angle, M.P., Powers, D.M., Swinford, E.M., 2012, Karst flooding in Bellevue, Ohio, and vicinity—2008: Ohio Department of Natural Resources, Division of Geological Survey Map EG-5, scale 1:24,000.

Pavey, R.R., Hull, D.N., Brockman, C.S., Schumacher, G.A., Stith, D.A., Swinford, E.M., Sole, T.L., Vorbau, K.E., Kallini, K.D., Evans, E.E., Slucher, E.R., and Van Horn, R.G., with GIS and cartography by Powers, D.M., and Vogt, K.L., 1999, Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, scale 1:500,000. [Revised 2002, 2004, 2007.]

Raab, James, Haiker, Bill, Jones, Wayne, Angle, Michael, Pavey, Rick, Swinford, Mac, and Powers, Donovan, 2009, Ground water induced flooding in the Bellevue Ohio area, spring and summer 2008: Ohio Department of Natural Resources, Division of Water Technical Report of Investigation 2009-1, 19 p., accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/Karst/Bellevue_Final_Report.pdf > .

Further Reading

For more information on karst in Ohio, visit the Ohio Geological Survey website, **OhioGeology.com.** The following resources also provide additional information on karst and its effects in Ohio and beyond.

Ohio Department of Natural Resources

Ground Water Induced Flooding in the Bellevue Ohio Area Spring and Summer 2008, ODNR Division of Water Technical Report of Investigation 2009-1, 19 p.

Karst Flooding in Bellevue, Ohio, and Vicinity—2008, ODNR Division of Geological Survey Map EG-5, 2012, scale 1:24,000.

Known and Probable Karst in Ohio, ODNR Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

American Geological Institute

Living with Karst—A Fragile Foundation, AGI Environmental Awareness Series, no. 4, accessible at < http://www.agiweb.org/environment/publications/karst.pdf > .

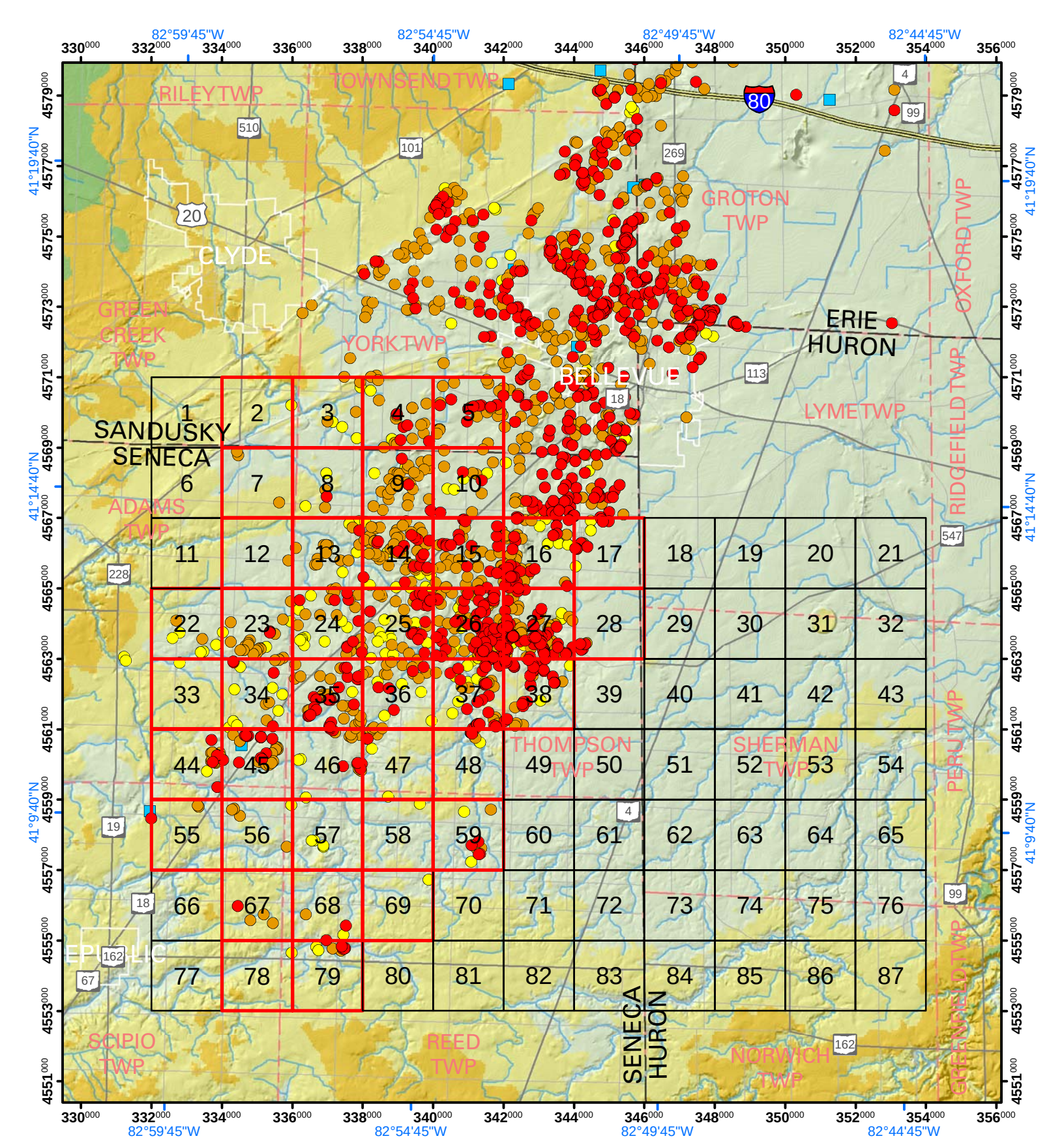
U.S. Geological Survey

USGS Groundwater Information, Karst and the USGS, accessible at < http://water.usgs.gov/ogw/karst/ > .

82°59'45"W
82°54'45"W
82°49'45"W
82°44'45"W
41°19'40"N
41°14'40"N
41°9'40"N
RILEY TWP
TOWNSEND TWP
GREEN CREEK TWP
FREMONT EAST
CLYDE
CLYDE
GROTON TWP
BELLEVUE
KIMBALL
OXFORD TWP
ERIE
HURON
YORK TWP
BELLEVUE
LYME TWP
RIDGEFIELD TWP
SANDUSKY
SENECA
ADAMS TWP
WATSON
THOMPSON TWP
SHERMAN TWP
PERU TWP
MONROEVILLE
FIRESIDE
FLAT ROCK
REPUBLIC
BLOOM
VILLE
SCIPIO TWP
ATTICA
REED TWP
SENECA
HURON
NORWICH TWP
CENTERTON
WILLARD
GREENFIELD TWP
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
Tiles containing karst features
U.S. National Grid
0 5 miles
0 10 kilometers
Scale 1:140,000
KARST FEATURE
Field verified
Suspect - field visited
Suspect - not visited
Spring
ELEVATION in feet
High : 972
Low : 603
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

82°59'45"W
82°54'45"W
82°49'45"W
82°44'45"W
41°19'40"N
41°14'40"N
41°9'40"N
RILEY TWP
TOWNSEND TWP
CLYDE
GREEN CREEK TWP
YORK TWP
BELLEVUE
GROTON TWP
OXFORD TWP
RIDGEFIELD TWP
LYME TWP
ADAMS TWP
THOMPSON TWP
SHERMAN TWP
PERKINS TWP
REED TWP
SCIPIO TWP
NORWICH TWP
GREENFIELD TWP
SANDUSKY
SENECA
ERIE
HURON
SENECA
HURON
St
Sbi
Dc
Dd
Ssu
Dolpb
Doh
Dol
EPHRAIM
1 2 3 4 5
6 7 8 9 10
11 12 13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 28 29 30 31 32
33 34 35 36 37 38 39 40 41 42 43
44 45 46 47 48 49 50 51 52 53 54
55 56 57 58 59 60 61 62 63 64 65
66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84 85 86 87
Tiles containing karst features
U.S. National Grid
KARST FEATURE
Field verified
Suspect - field visited
Suspect - not visited
Spring
BEDROCK GEOLOGY
Doh Ohio Sh
Dolp Prout Ls
Dol Olentangy Sh
Dolpb Plum Brook Sh
Dd Delaware Ls
Dc Columbus Ls
Sbi Bass Islands Dol
Ssu Salina undiff
St Tymochtee Dol
0 5 miles
0 Scale 1:140,000 10 kilometers
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.



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0 0.5 miles

0 Scale 1:12,000 1 kilometers

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

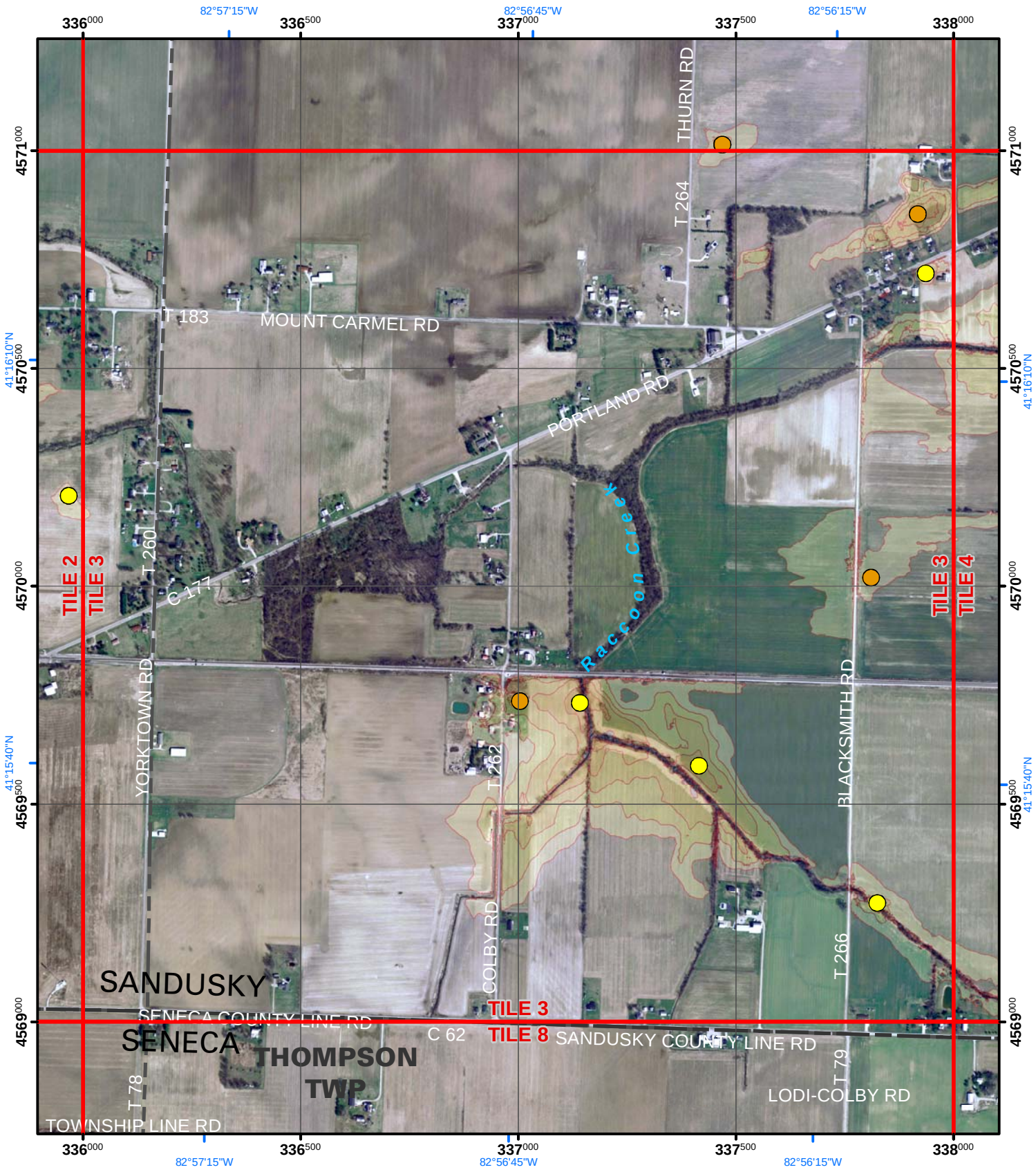
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 3



U.S. National Grid

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Grid Zone Designation: **17S**

0 — 0.5 miles

0 — 1 kilometers

Scale 1:12,000

N W E S

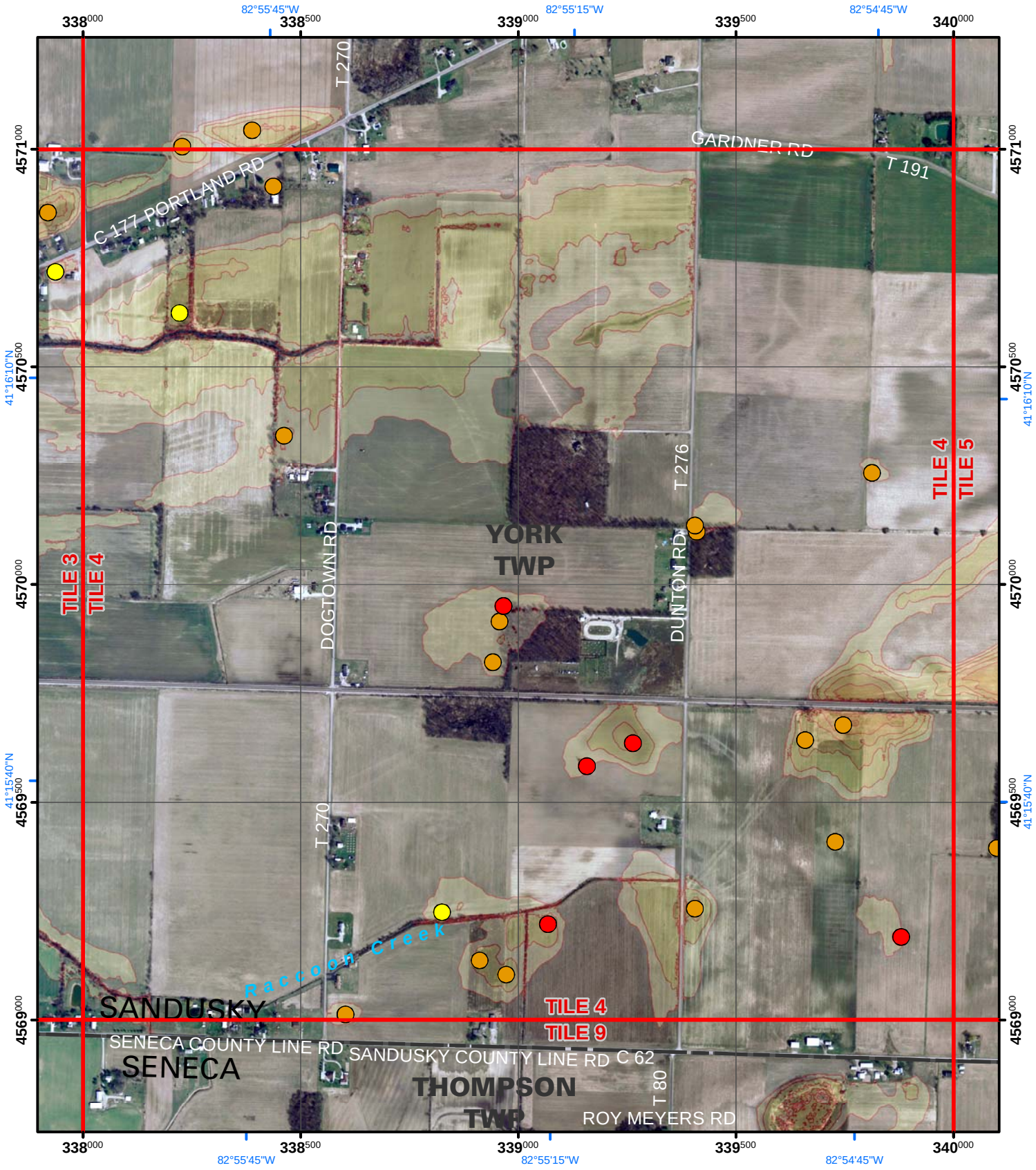
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 4



U.S. National Grid

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Grid Zone Designation: **17S**

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0 — 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

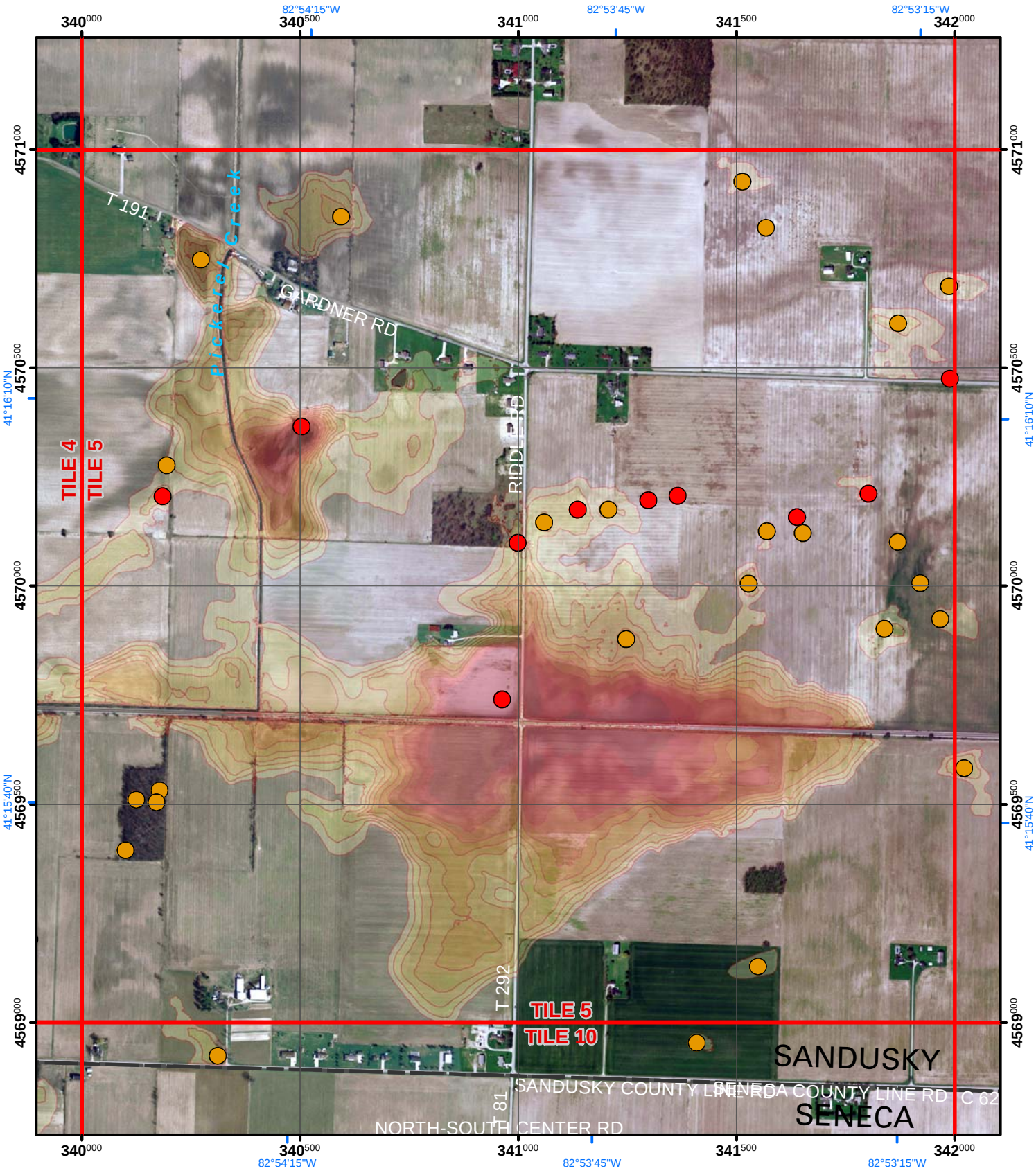
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 5



U.S. National Grid

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Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

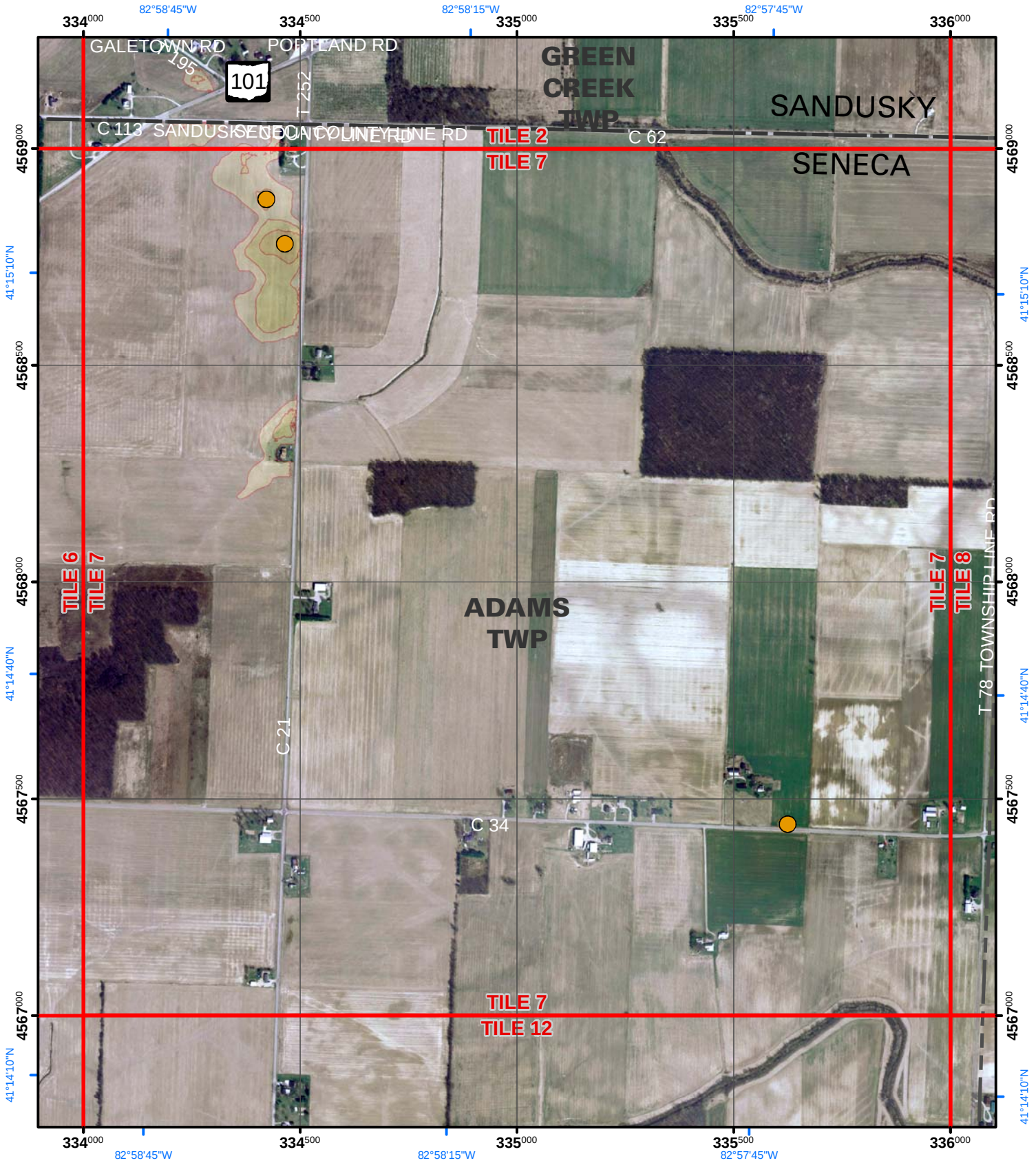
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 7



U.S. National Grid

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Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

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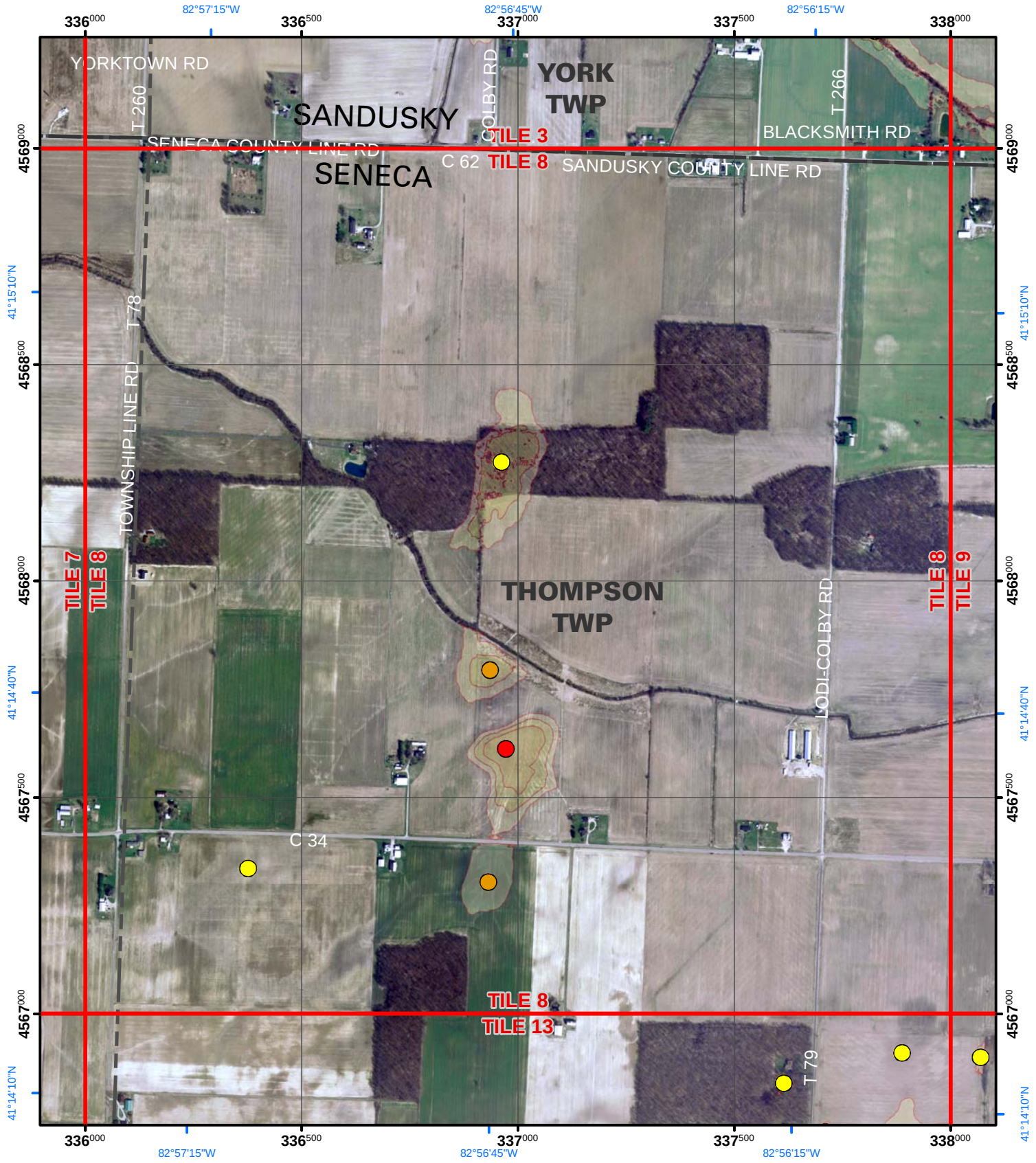
2	6	10
3	7	
4	8	

Tile Number: 8



U.S. National Grid

100,000-m Square ID Grid Zone Designation

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Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

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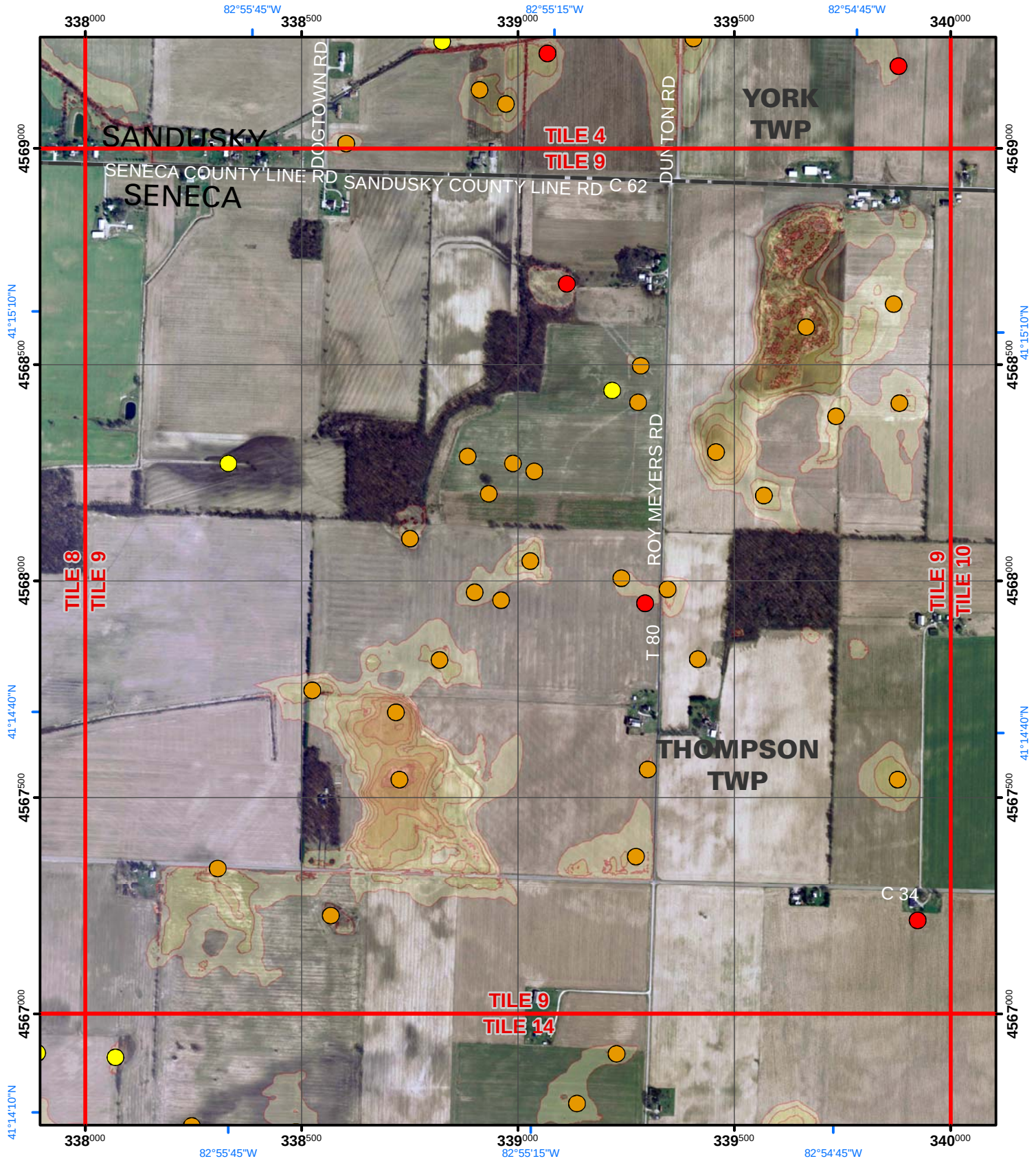
2	6	10
3	7	
4	8	

Tile Number: 9



U.S. National Grid

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Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

KARST FEATURE

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- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

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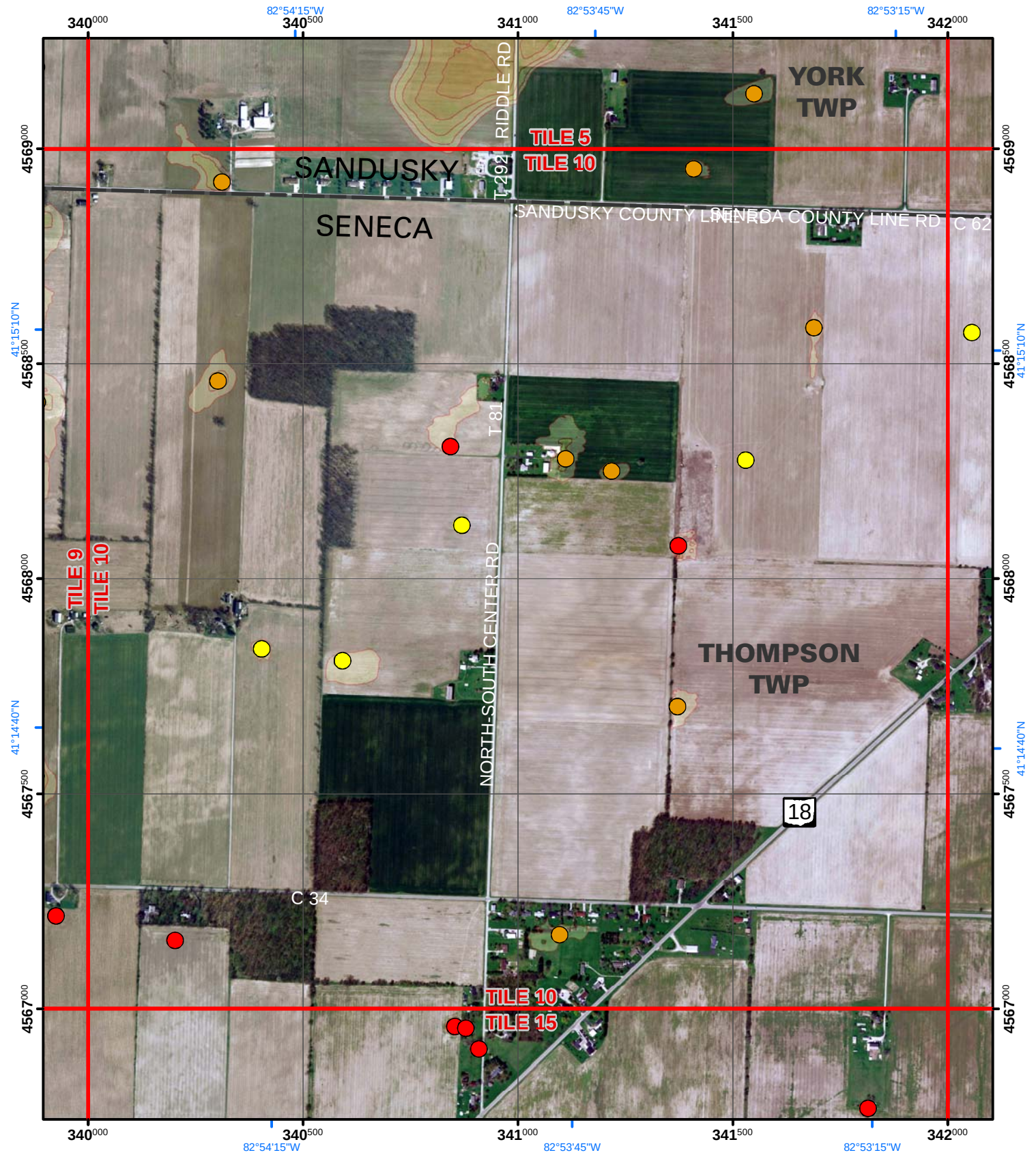
2	6	10
3	7	
4	8	

Tile Number: 10



U.S. National Grid
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0 1 kilometers
Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

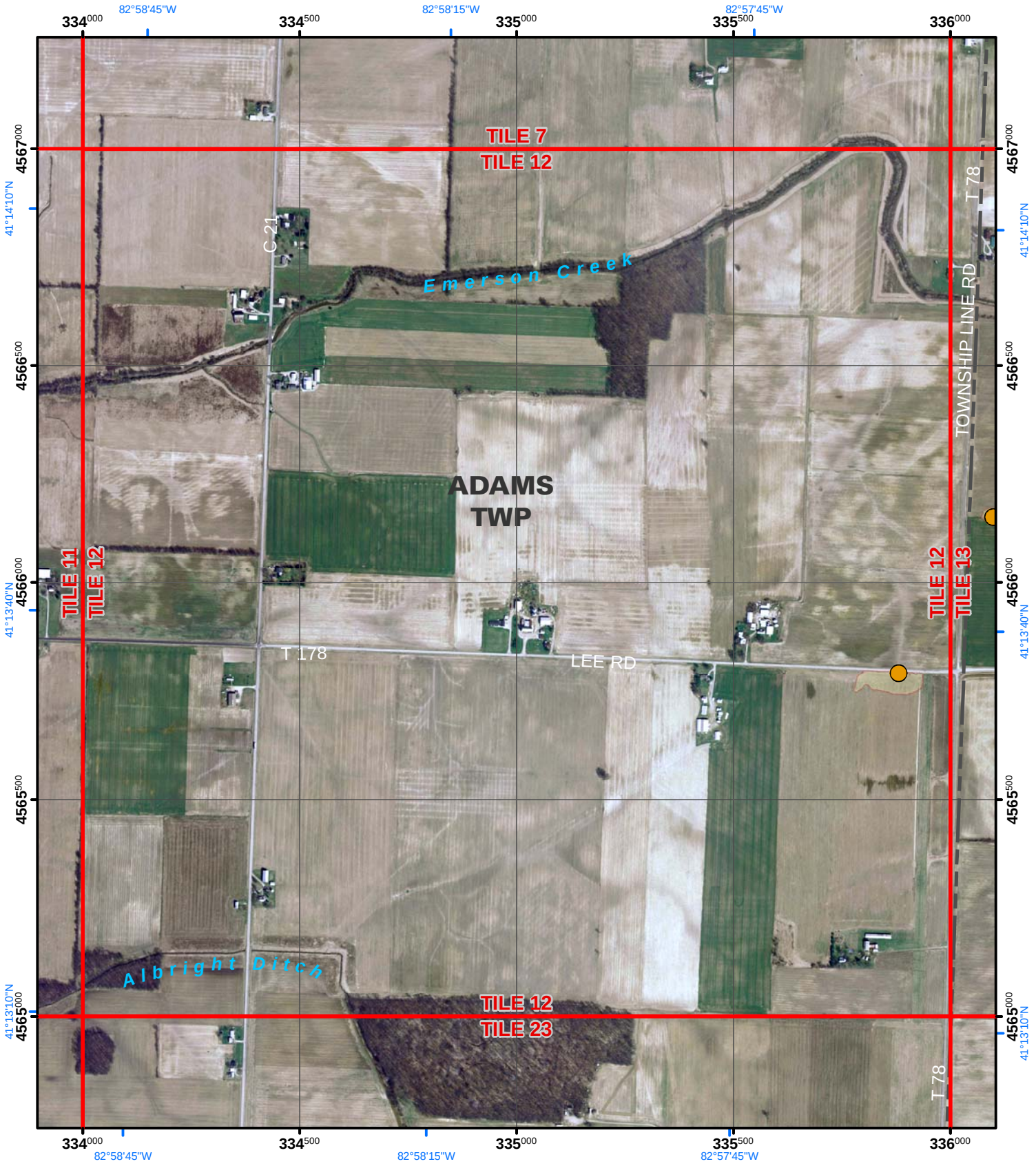
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 12



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

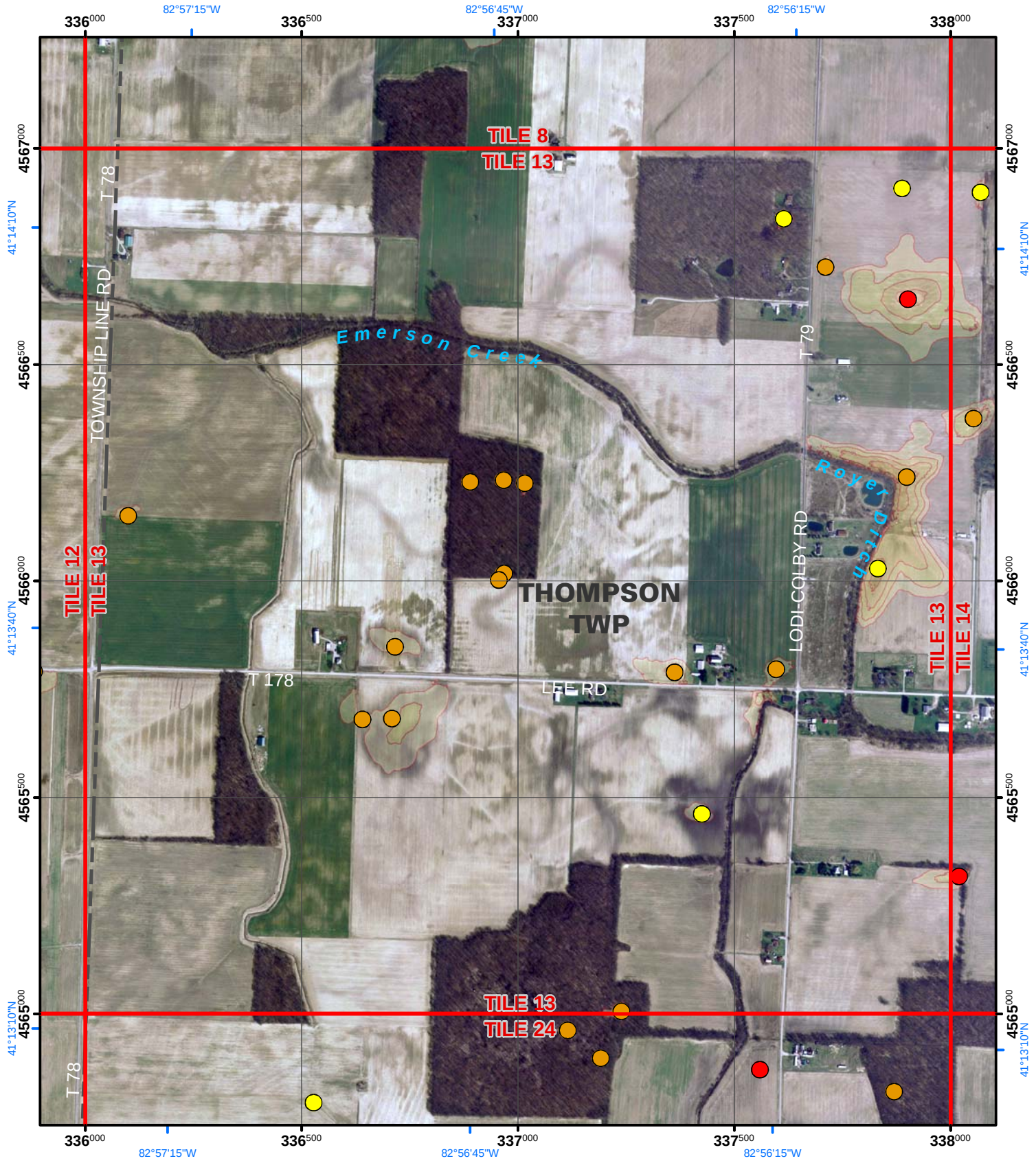
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 13



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 Scale 1:12,000 1 kilometers

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

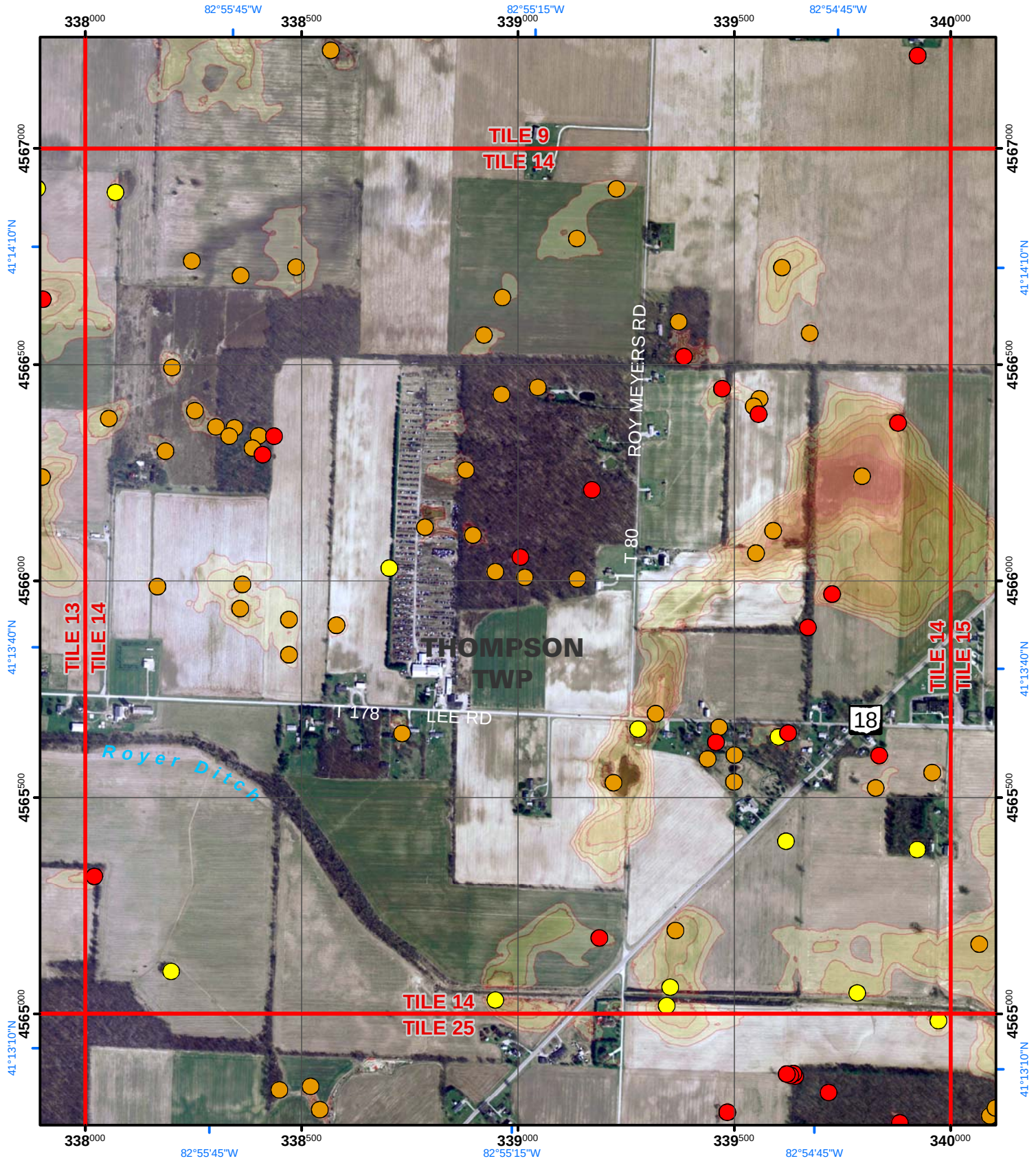
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 14



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 15

U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

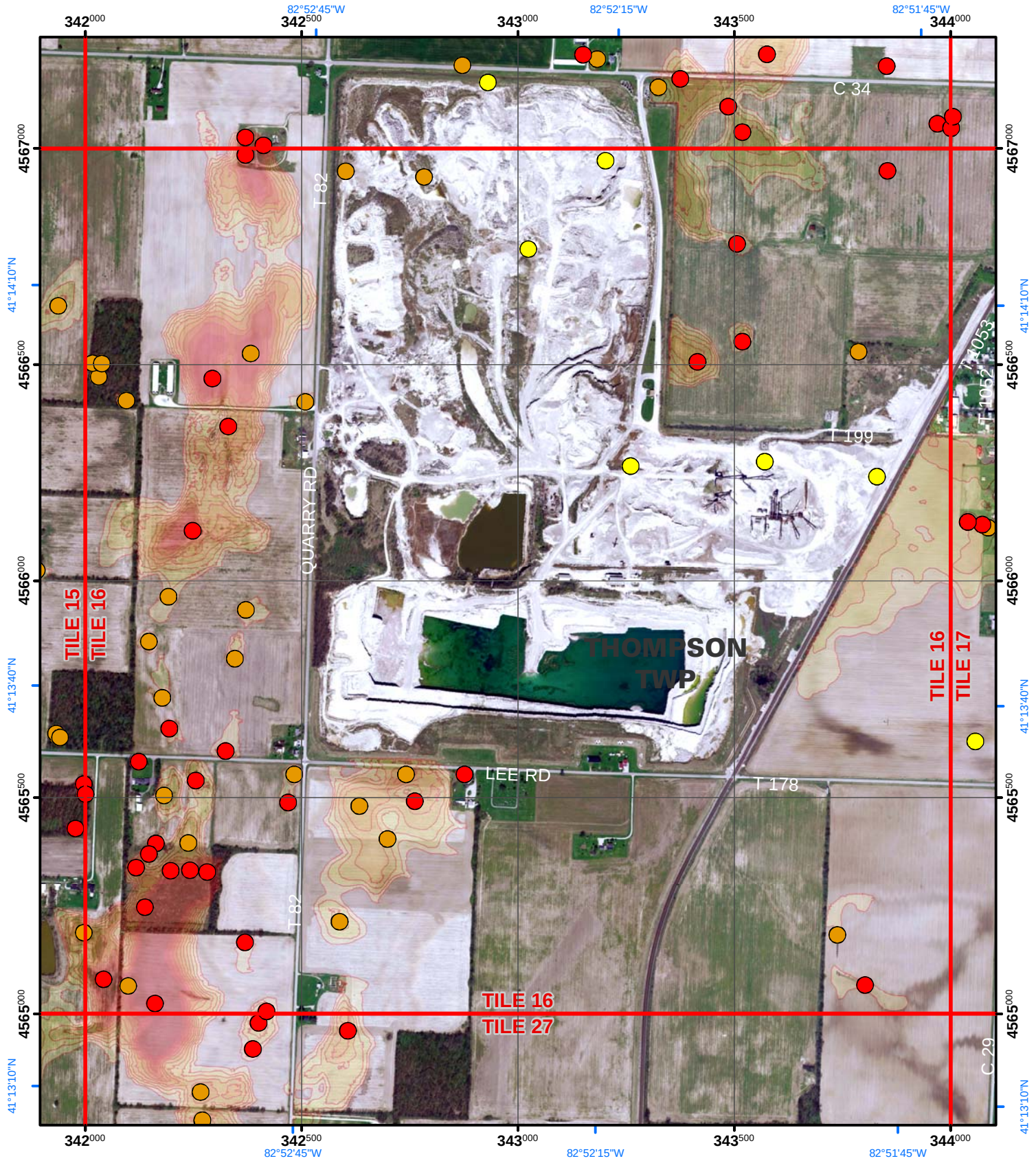
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 16



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

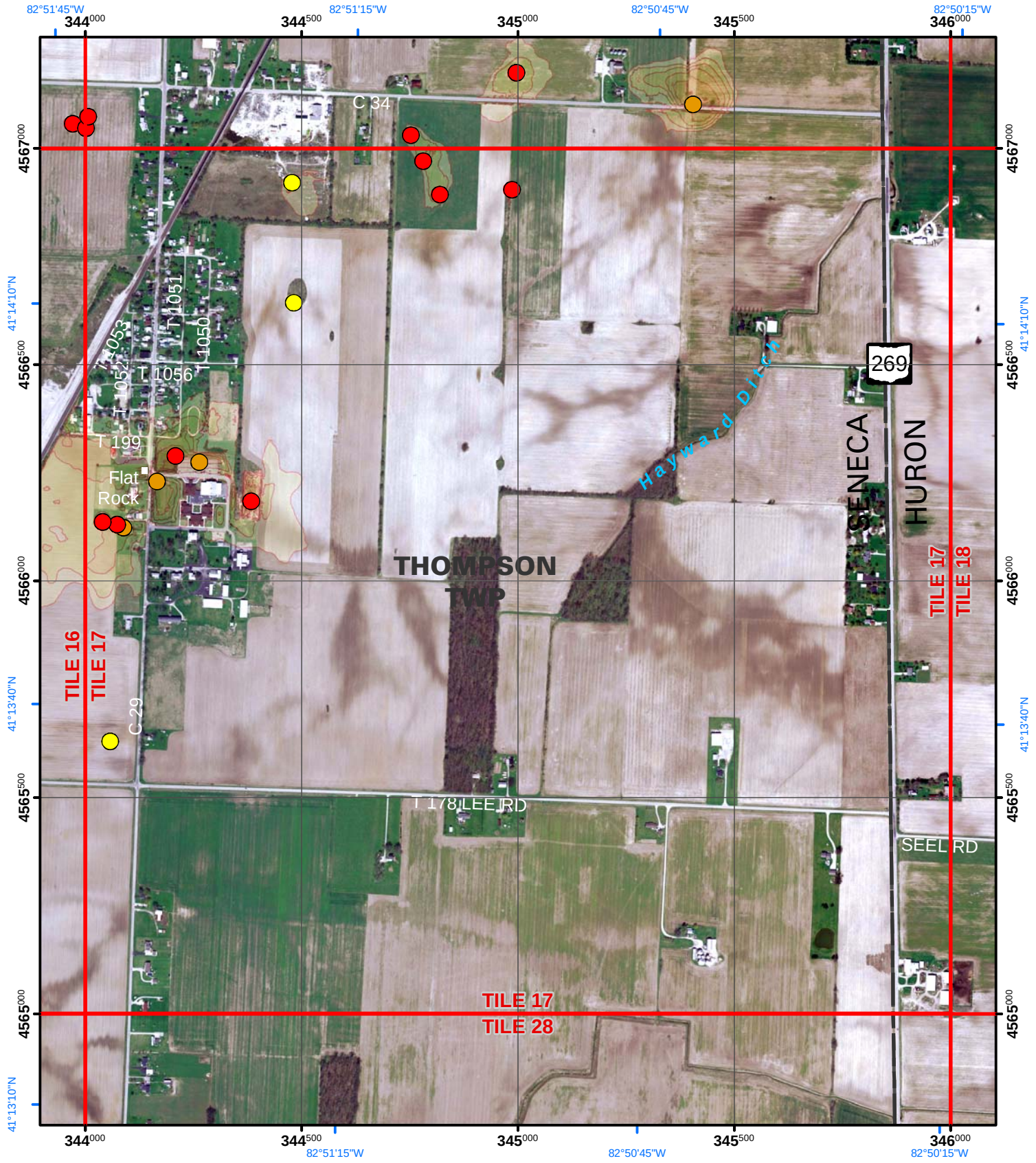
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 17



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 Scale 1:12,000 1 kilometers

N W E S

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

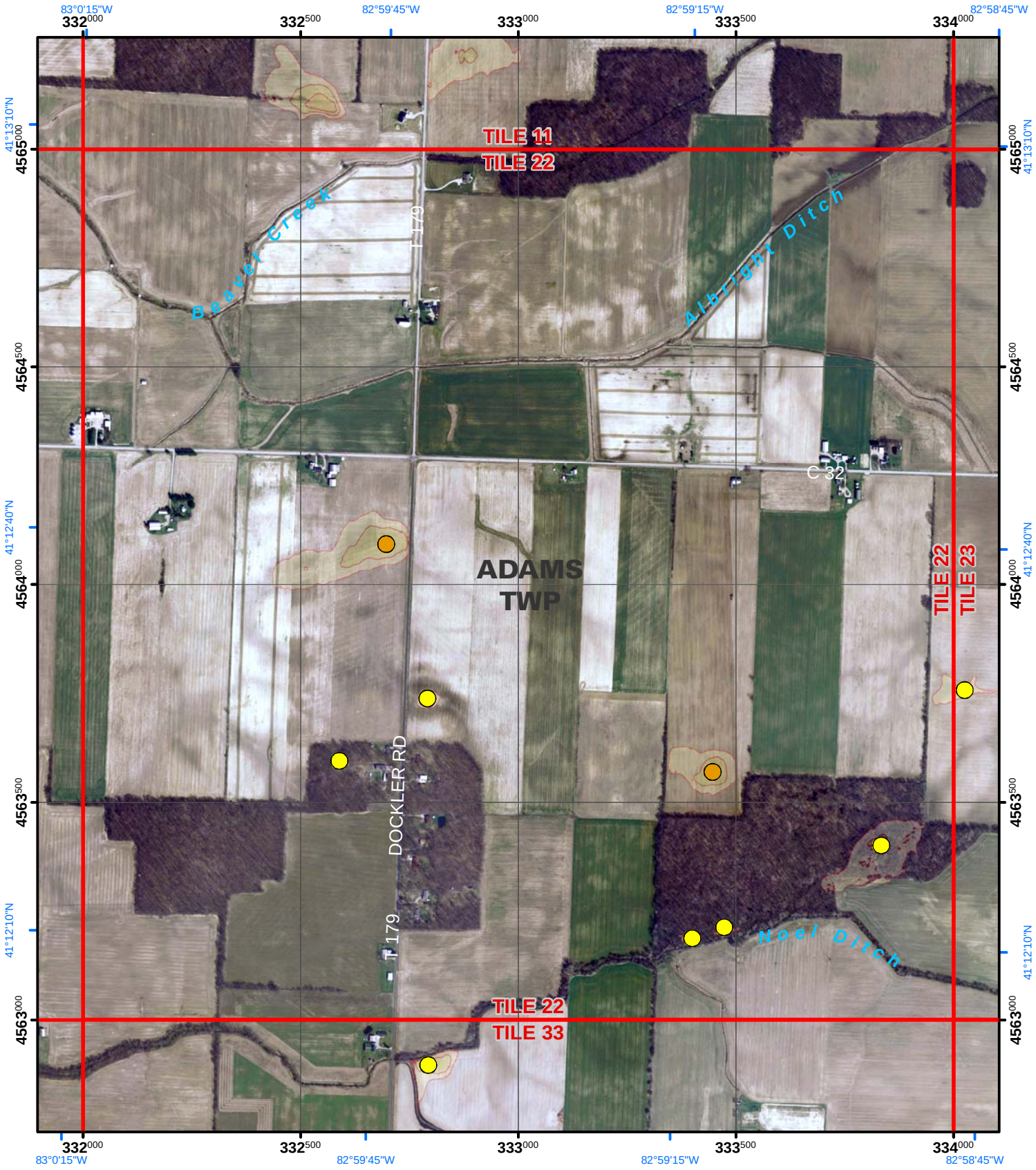
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 22



U.S. National Grid

100,000-m Square ID: **KE**

Grid Zone Designation: **17S**

0 — 0.5 miles

0 — 1 kilometers

Scale 1:12,000

N W E S

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

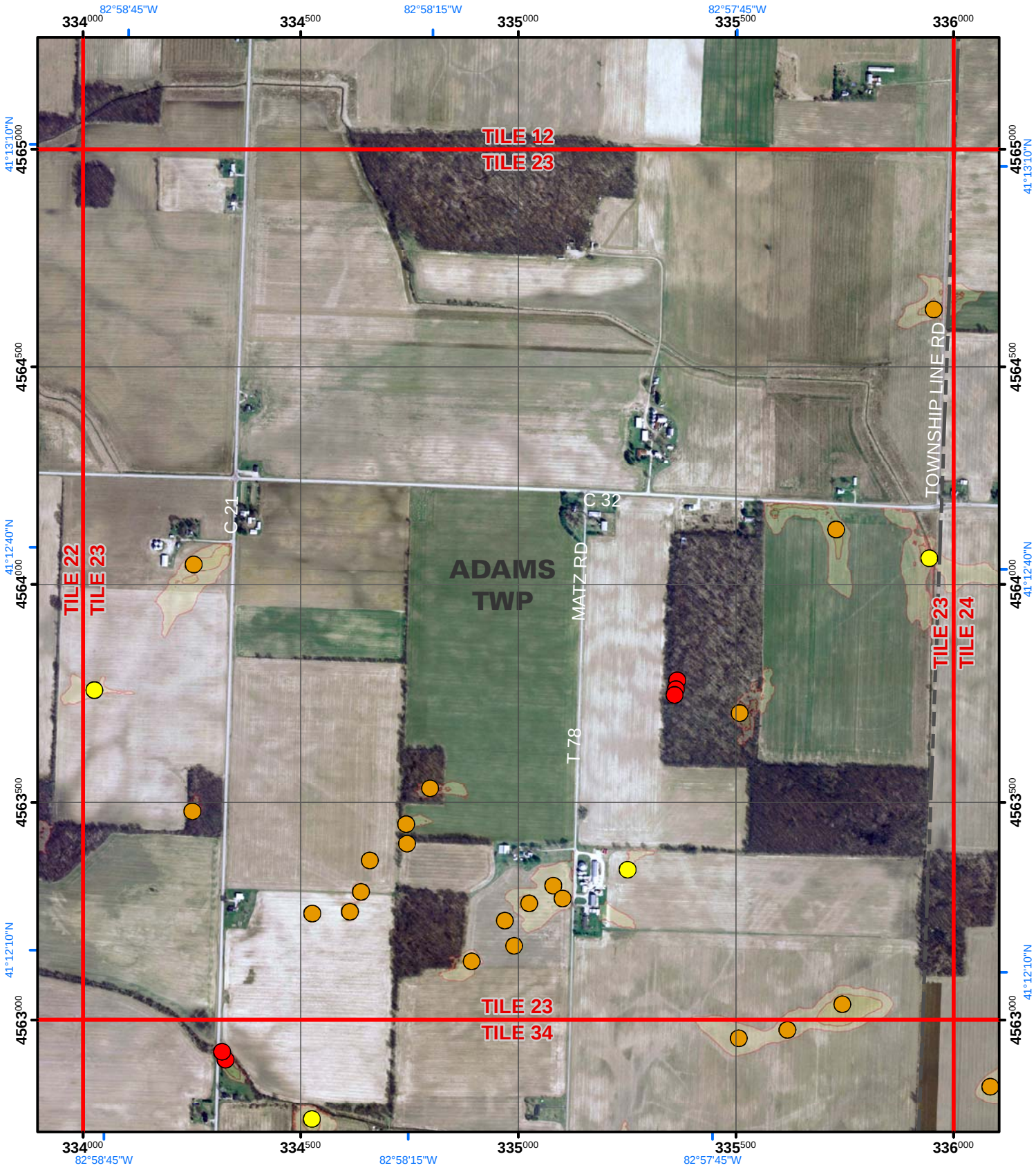
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 23



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

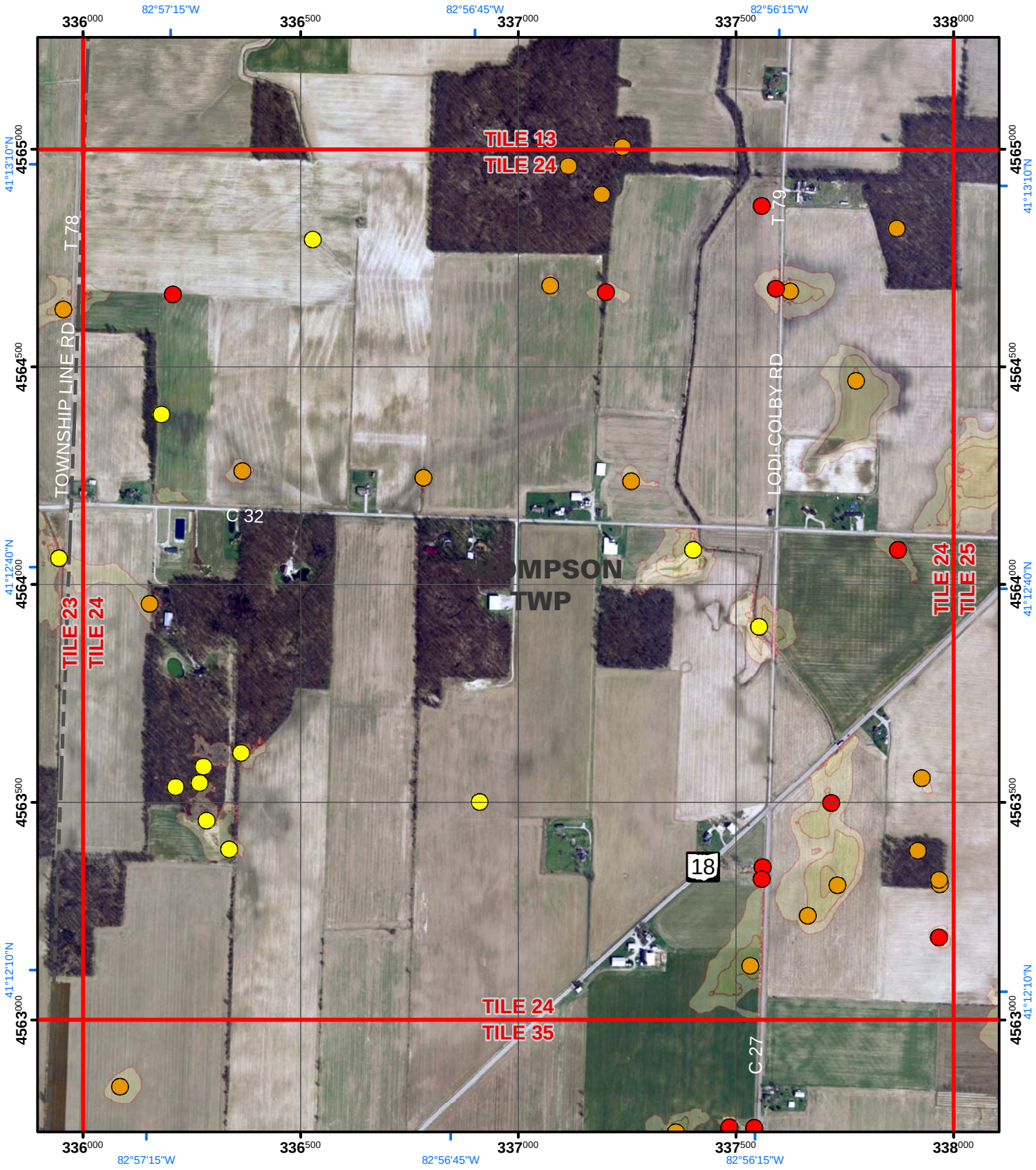
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 24



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

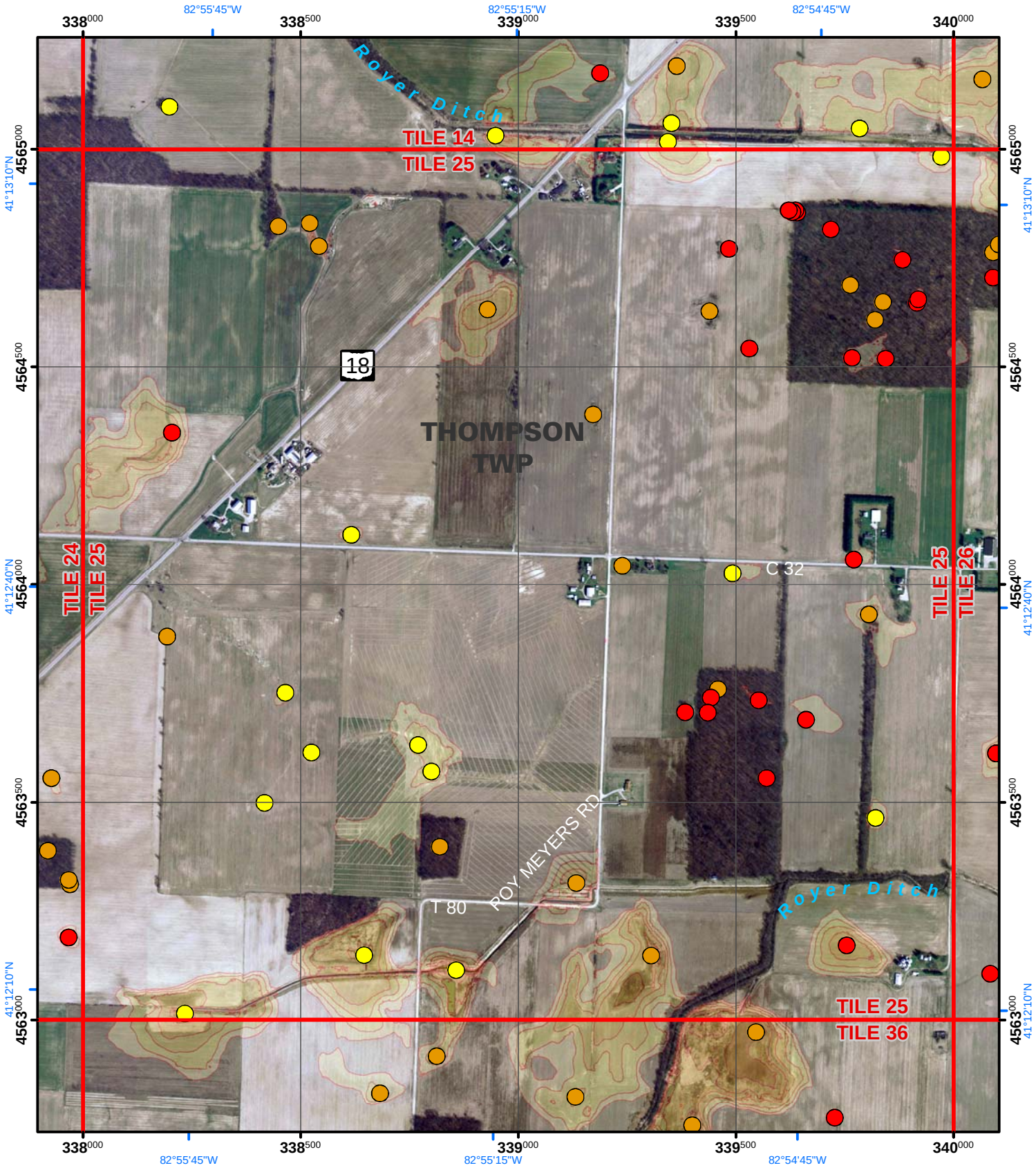
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 25



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

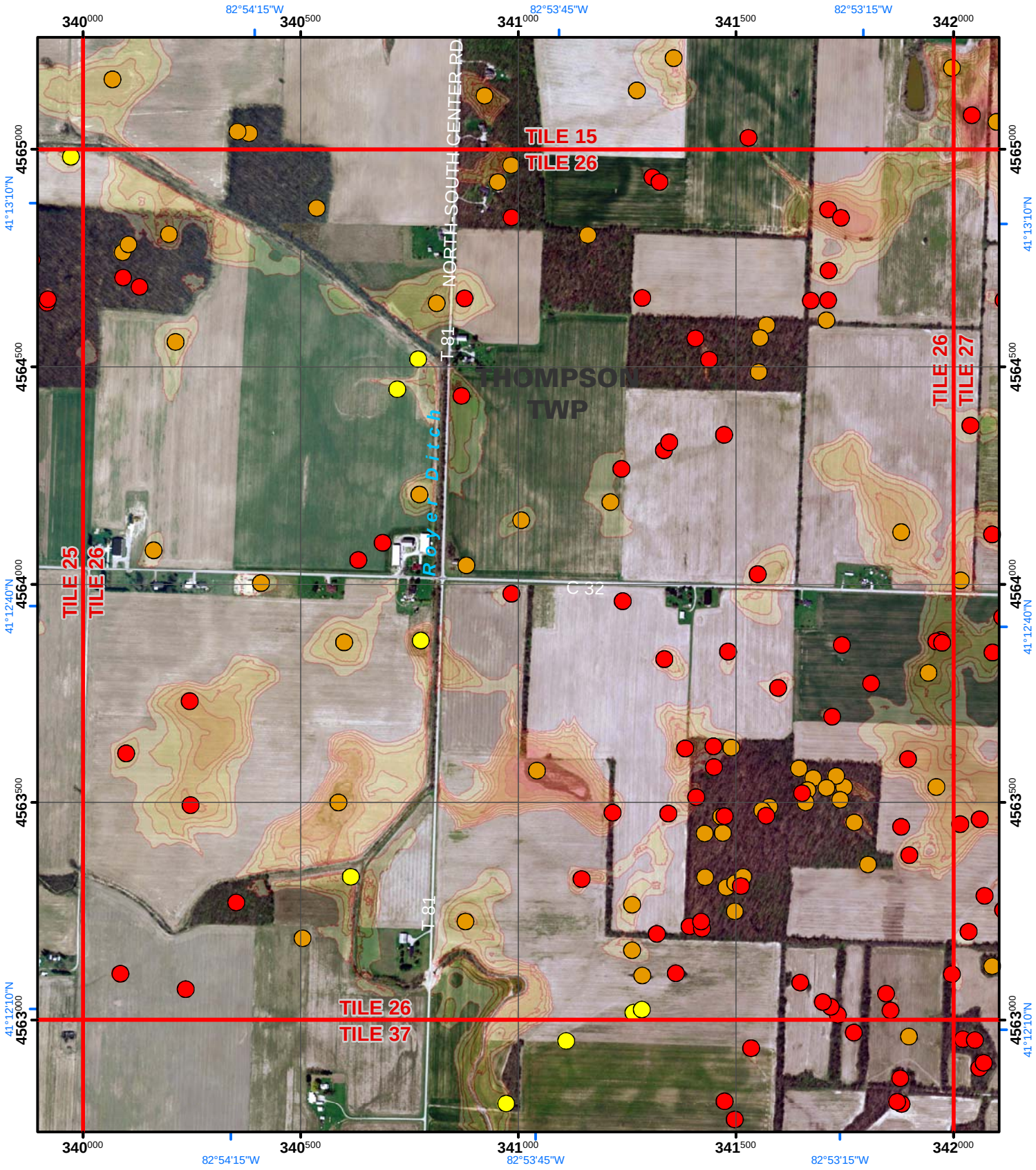
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 26



U.S. National Grid
100,000-m Square ID Grid Zone Designation
KE **17S**

0 0.5 miles
0 1 kilometers
Scale 1:12,000

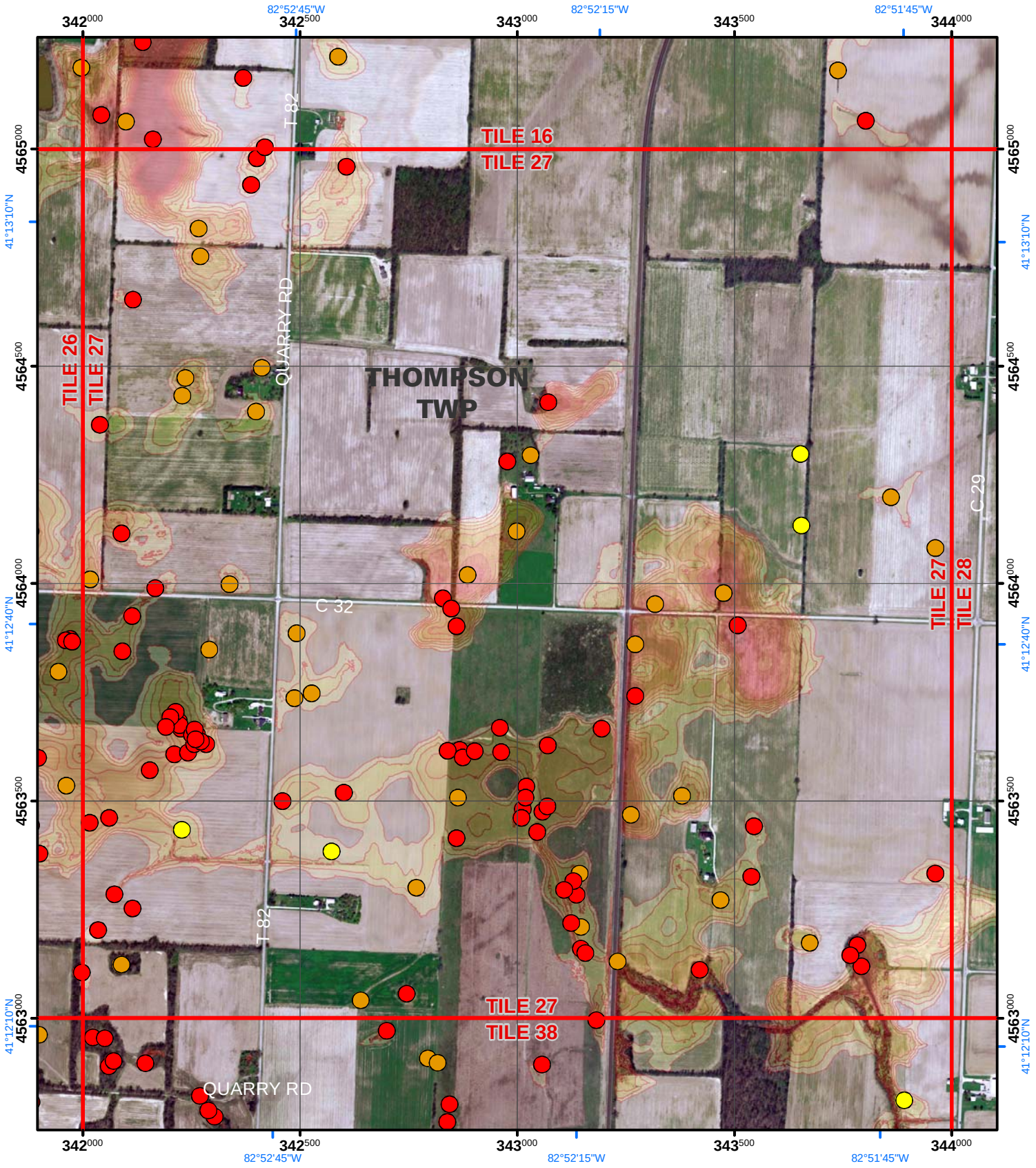
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 27



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 28

U.S. National Grid
100,000-m Square ID Grid Zone Designation
KE **17S**

0 0.5 miles
0 1 kilometers
Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

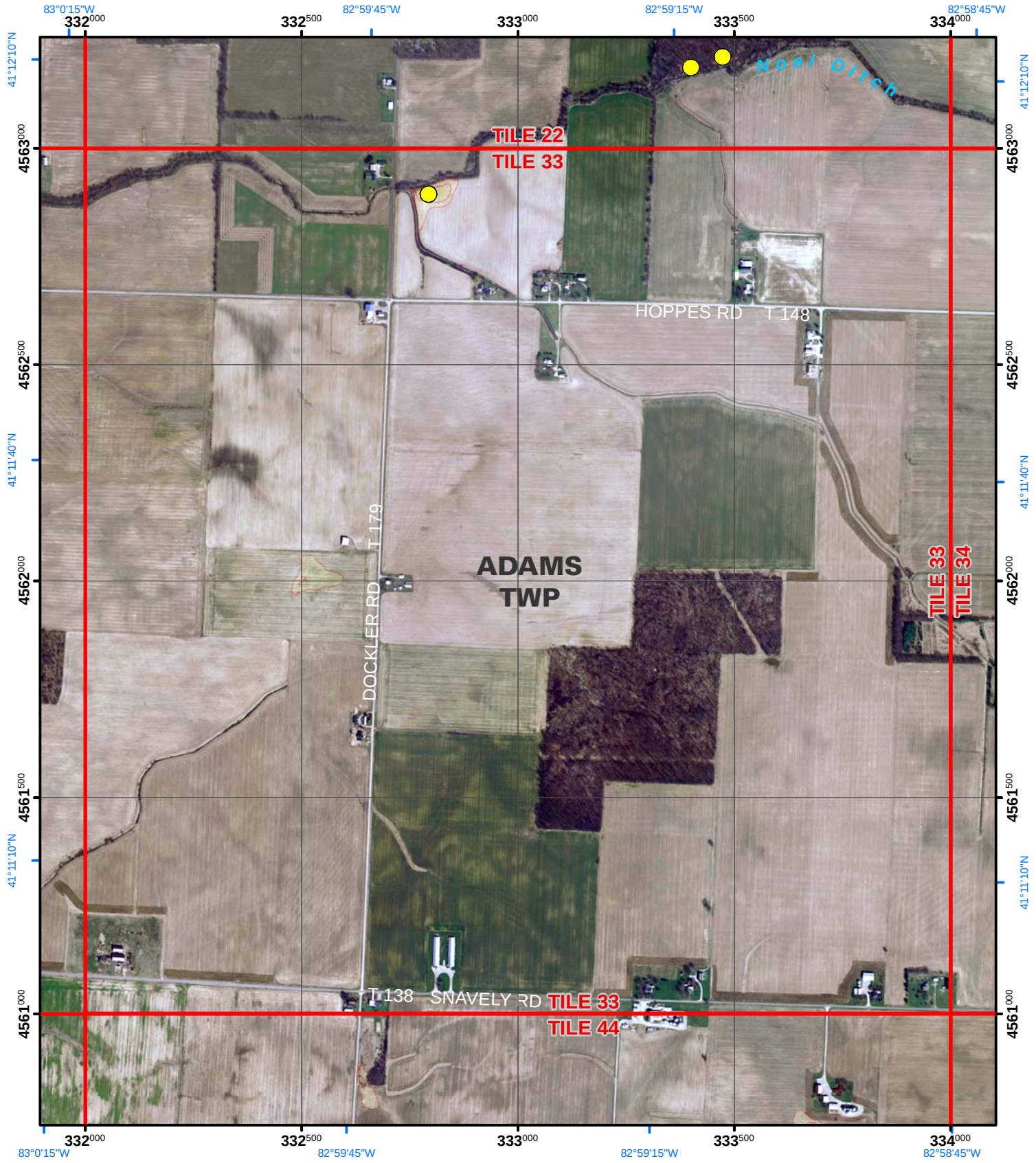
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 33



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

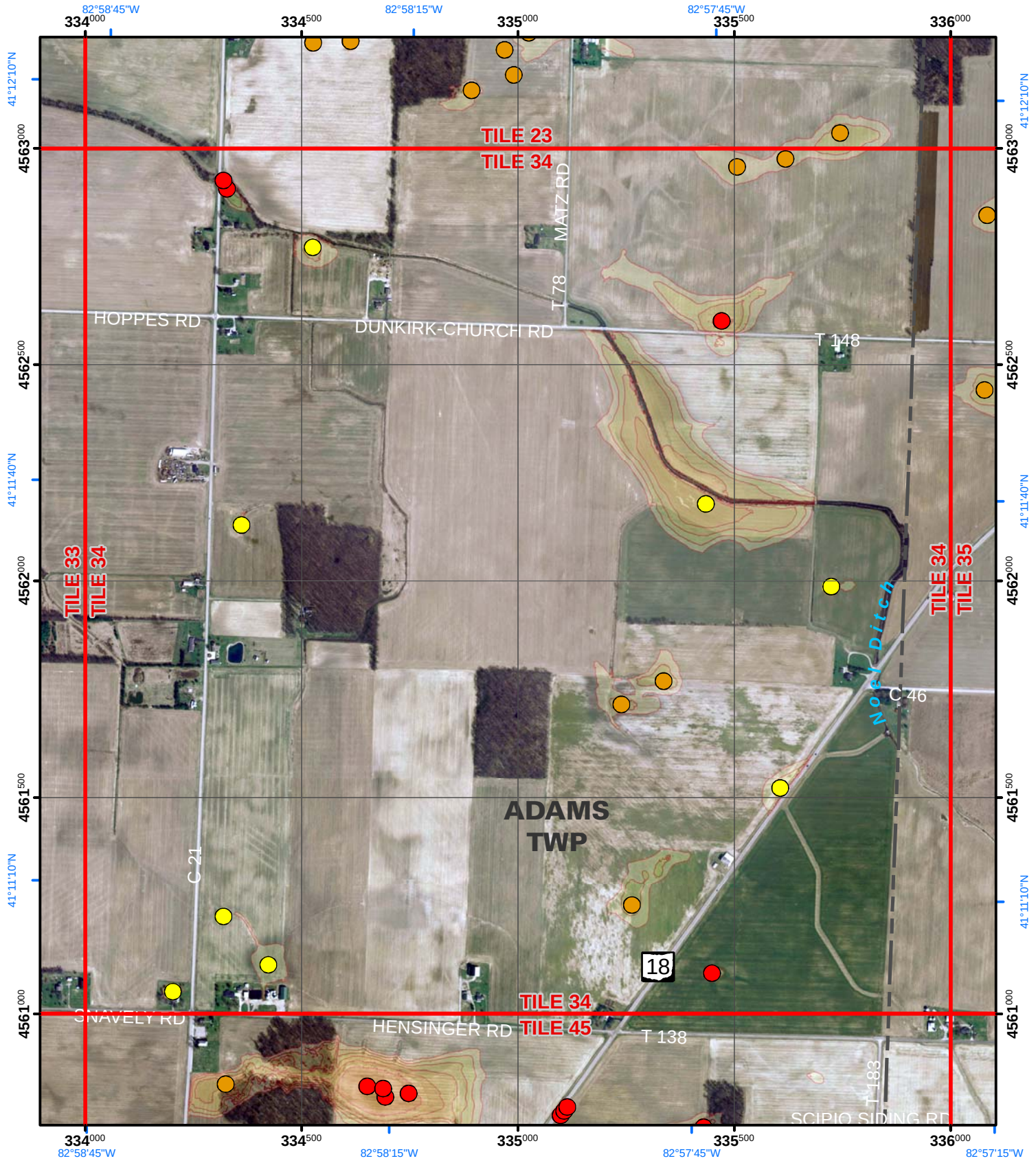
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 34



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

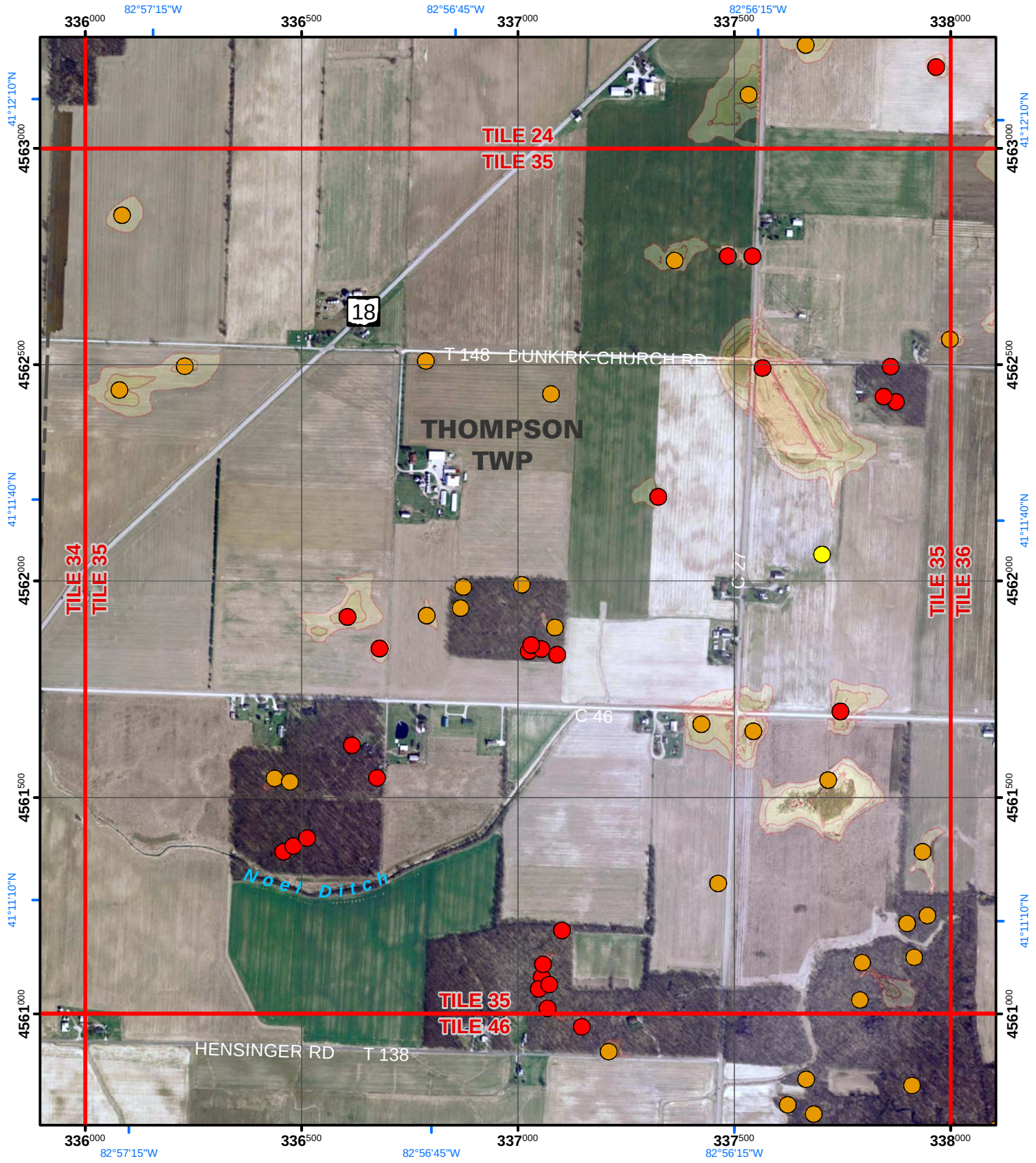
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1 2 3 4 5 6 7 8 9 10

Tile Number: 35



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

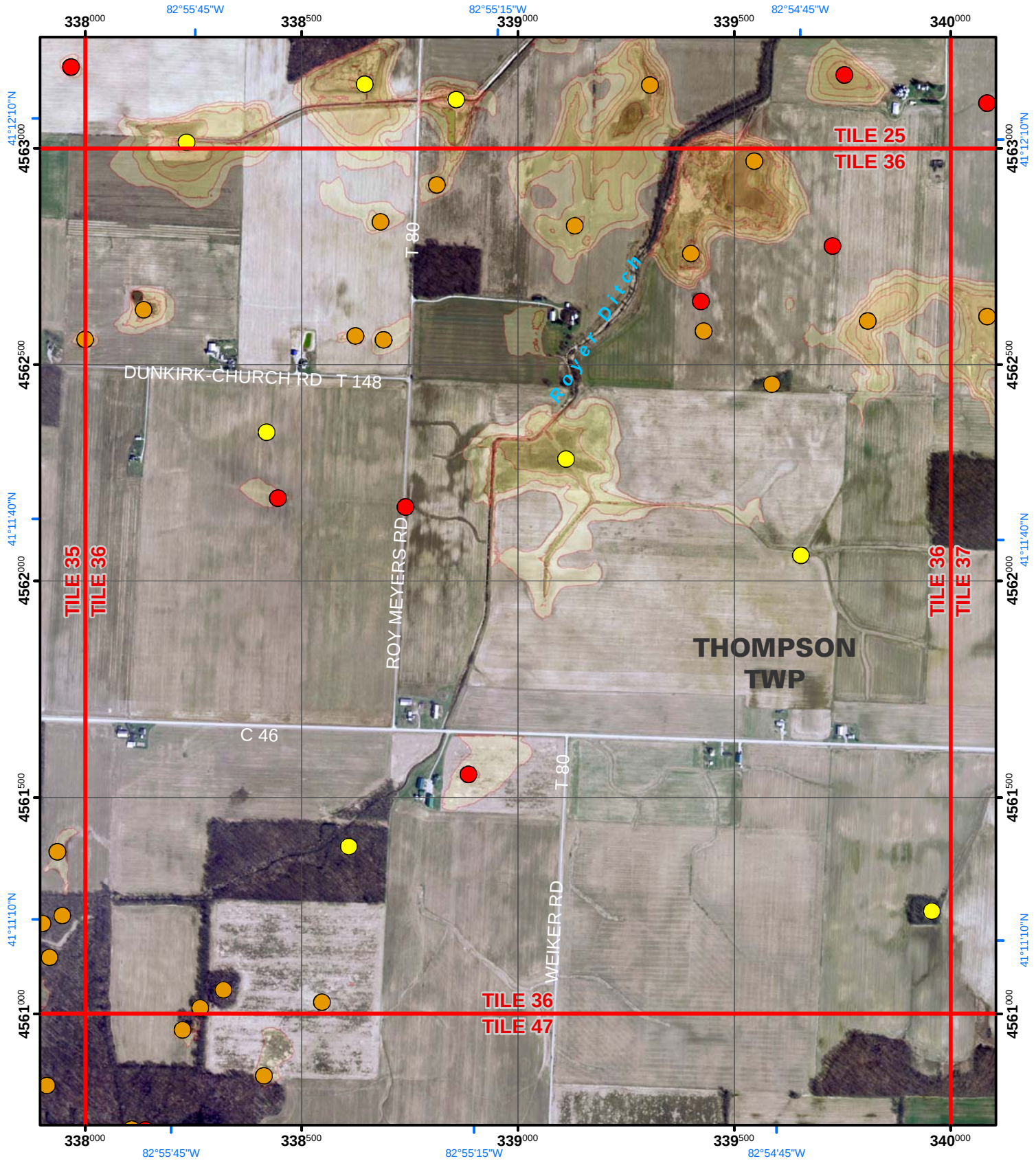
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 36



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

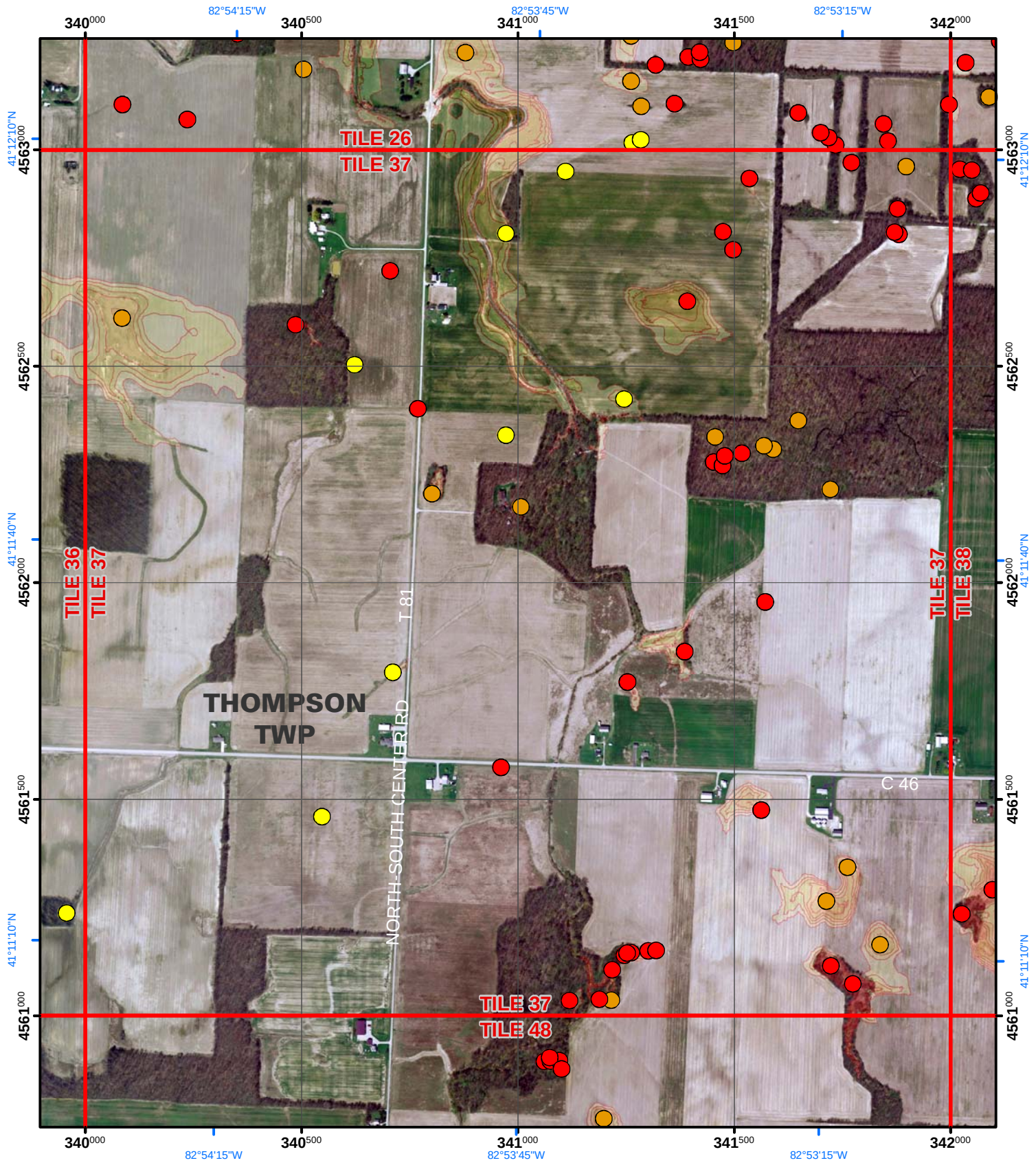
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 37



U.S. National Grid

100,000-m Square ID: **KE**

Grid Zone Designation: **17S**

0 — 0.5 miles

0 — 1 kilometers

Scale 1:12,000

N W E S

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

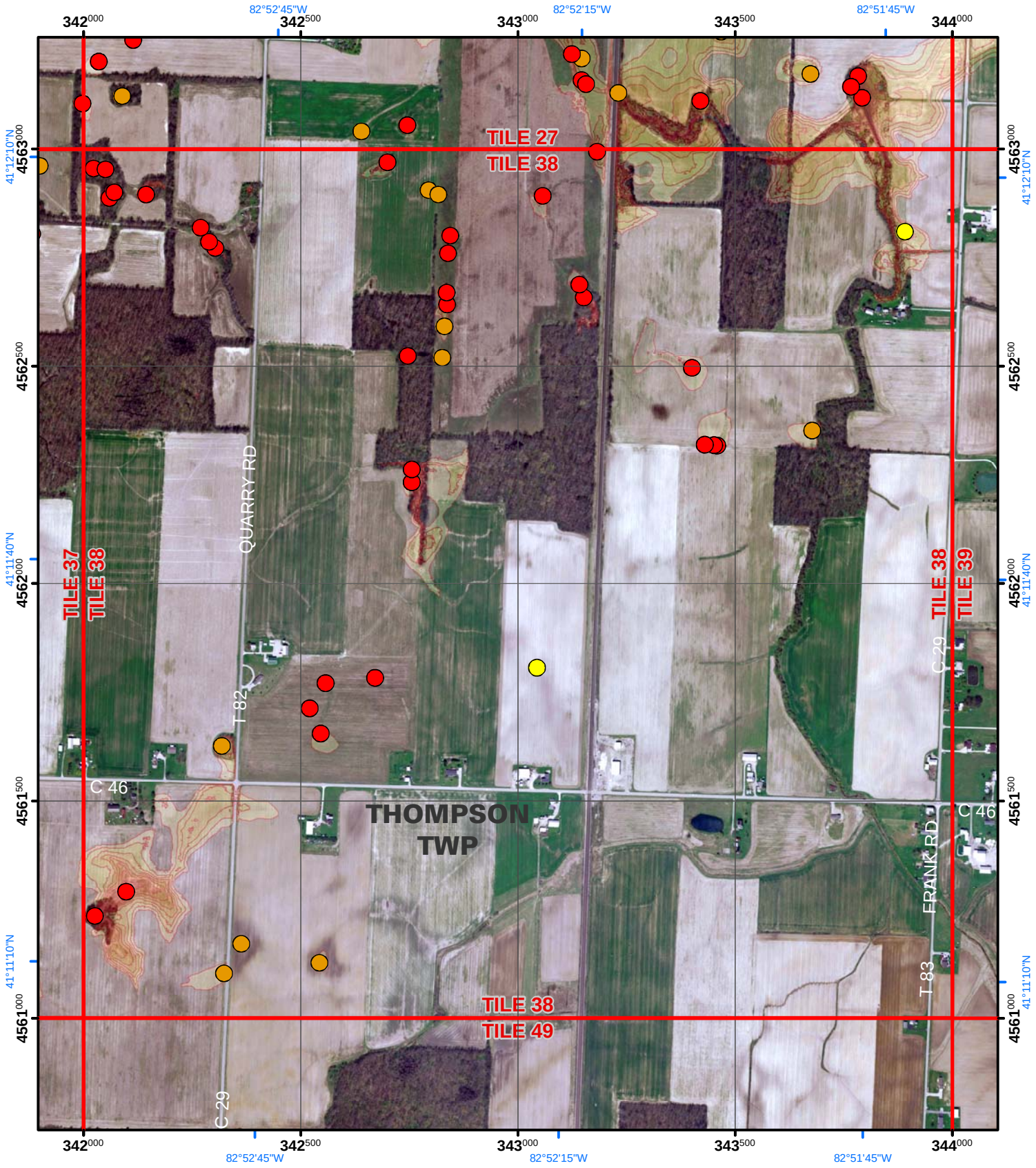
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 38



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

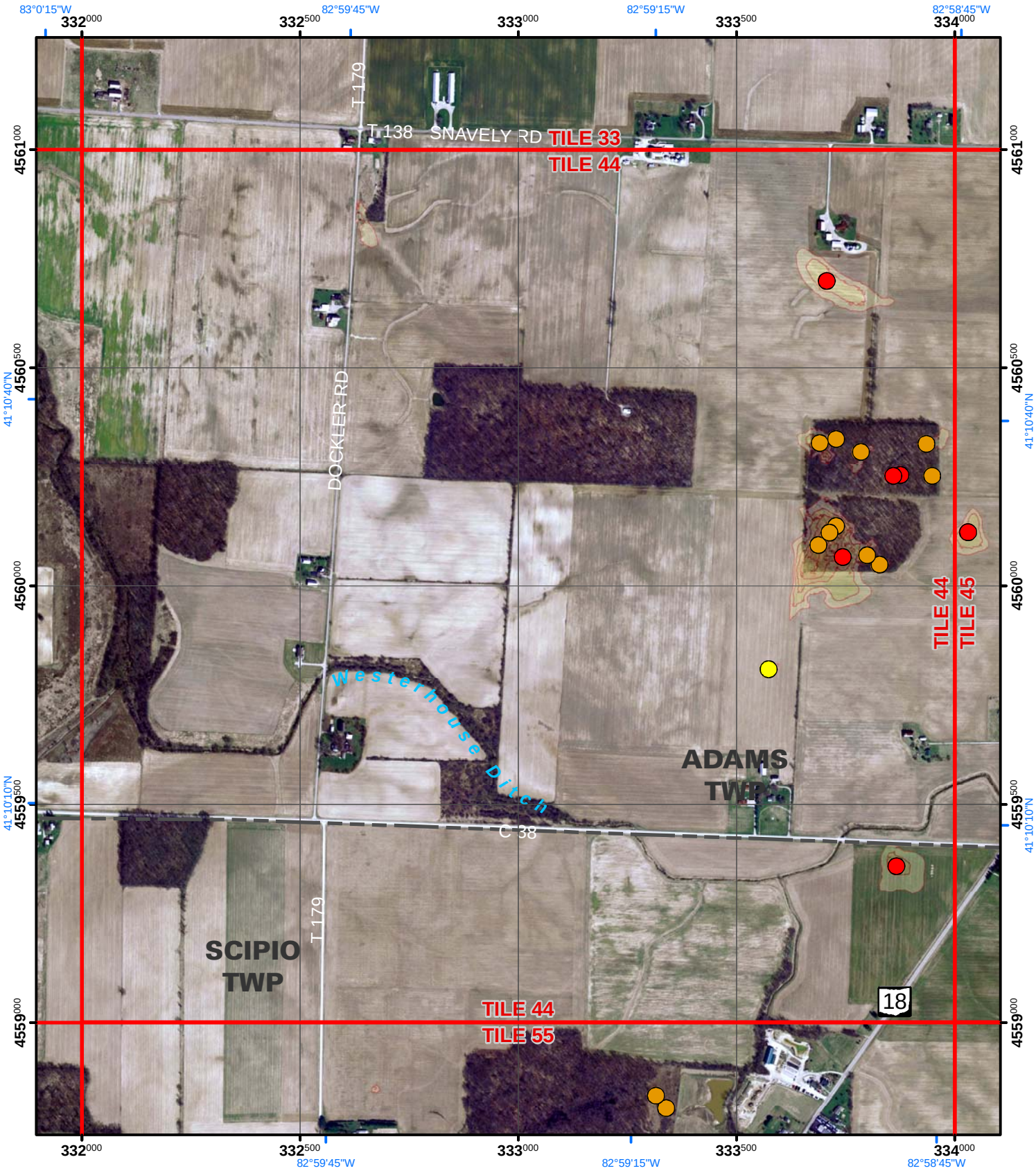
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 44



U.S. National Grid
100,000-m Square ID KE
Grid Zone Designation 17S

0 0.5 miles
0 1 kilometers
Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

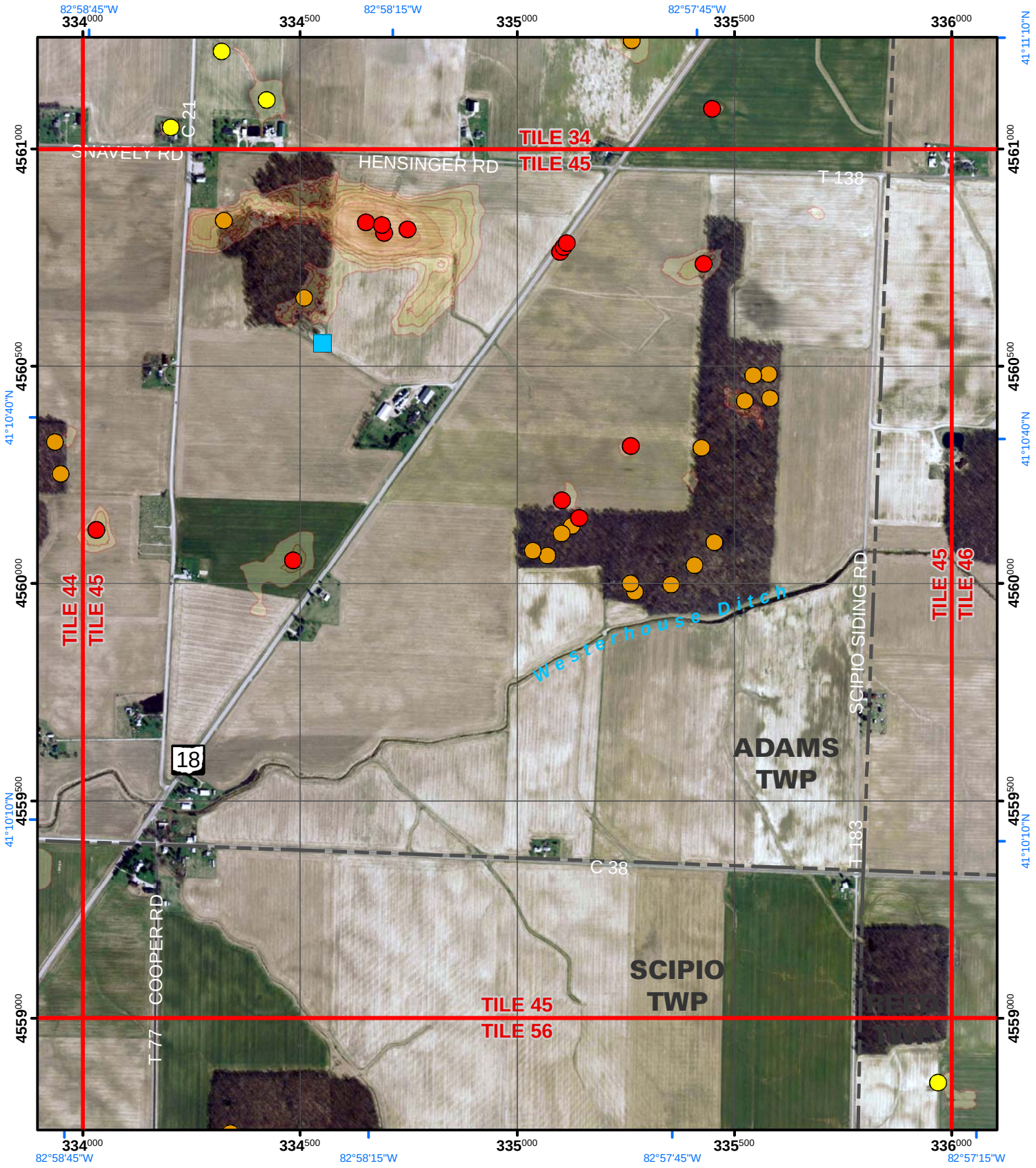
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 45



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

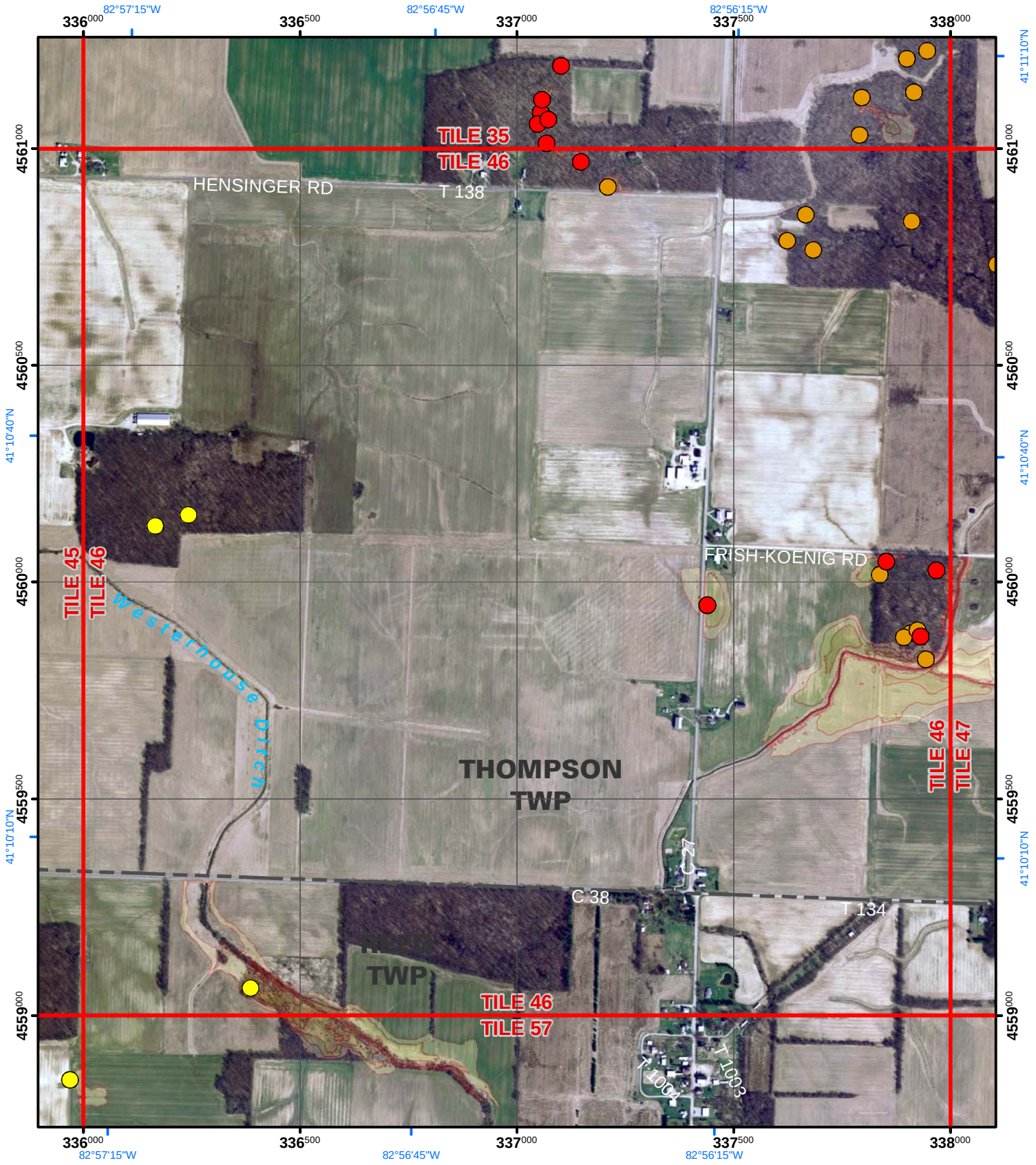
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 46



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

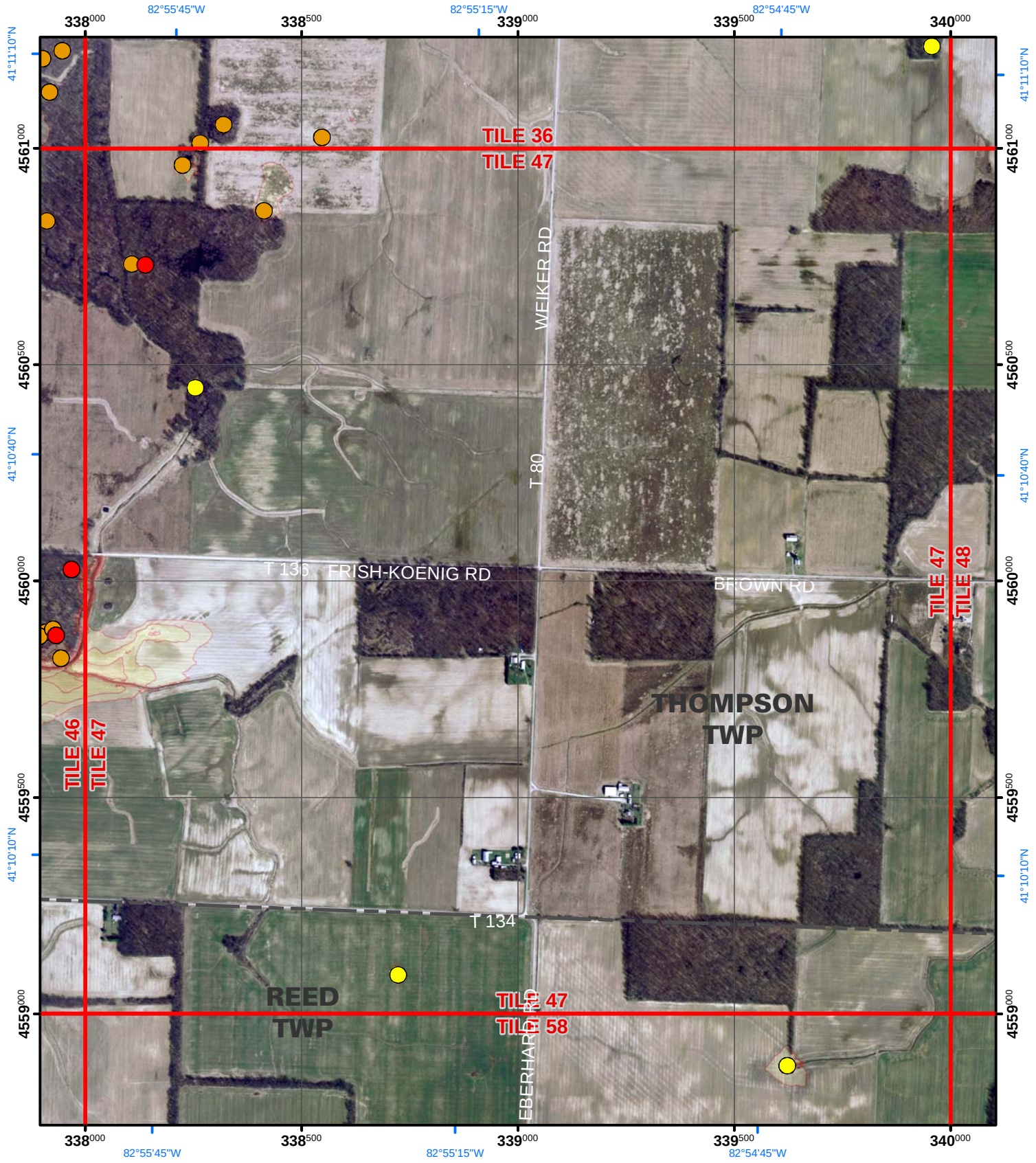
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 47



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

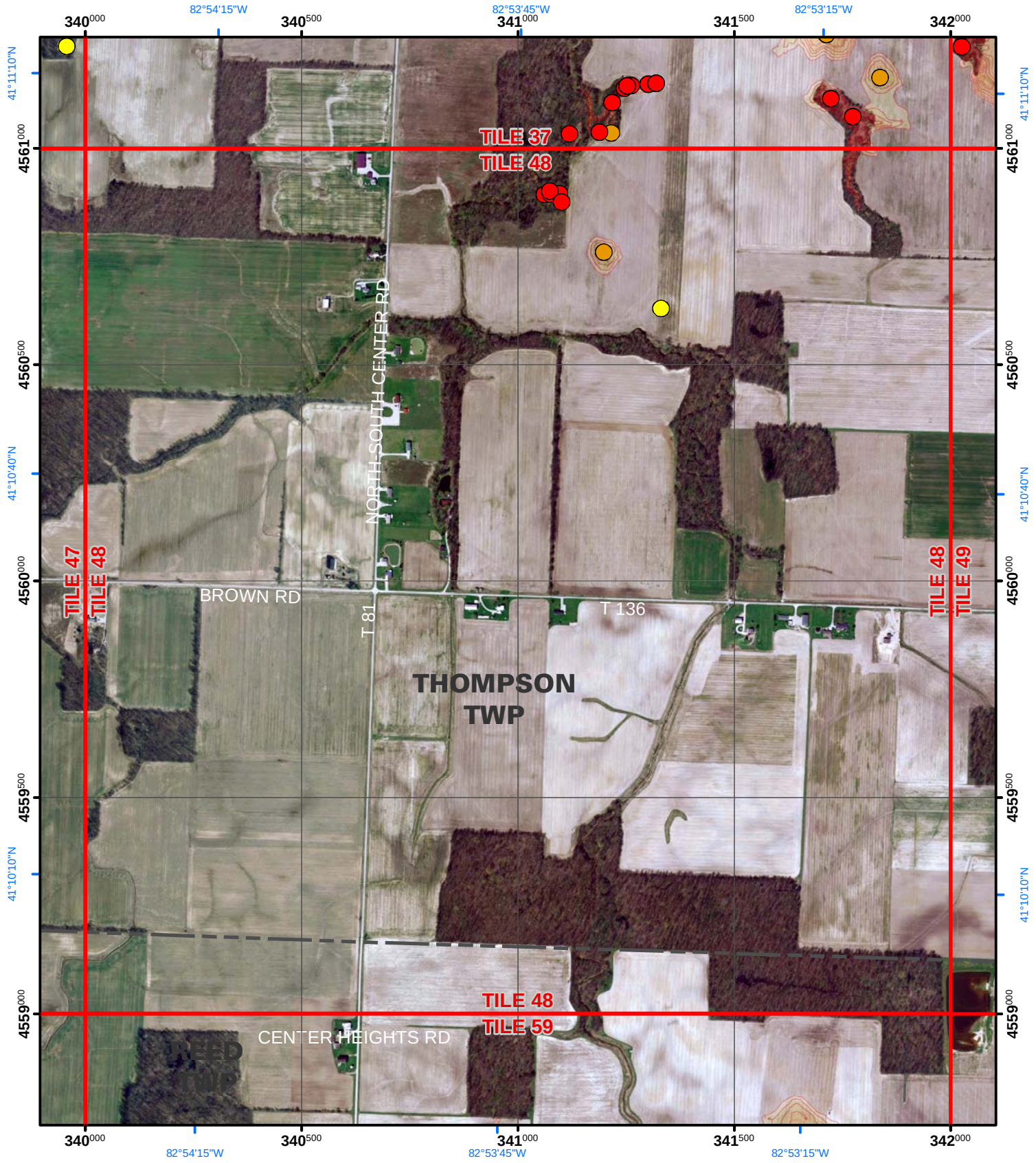
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 48



U.S. National Grid

100,000-m Square ID: **KE**

Grid Zone Designation: **17S**

0 — 0.5 miles

0 — 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

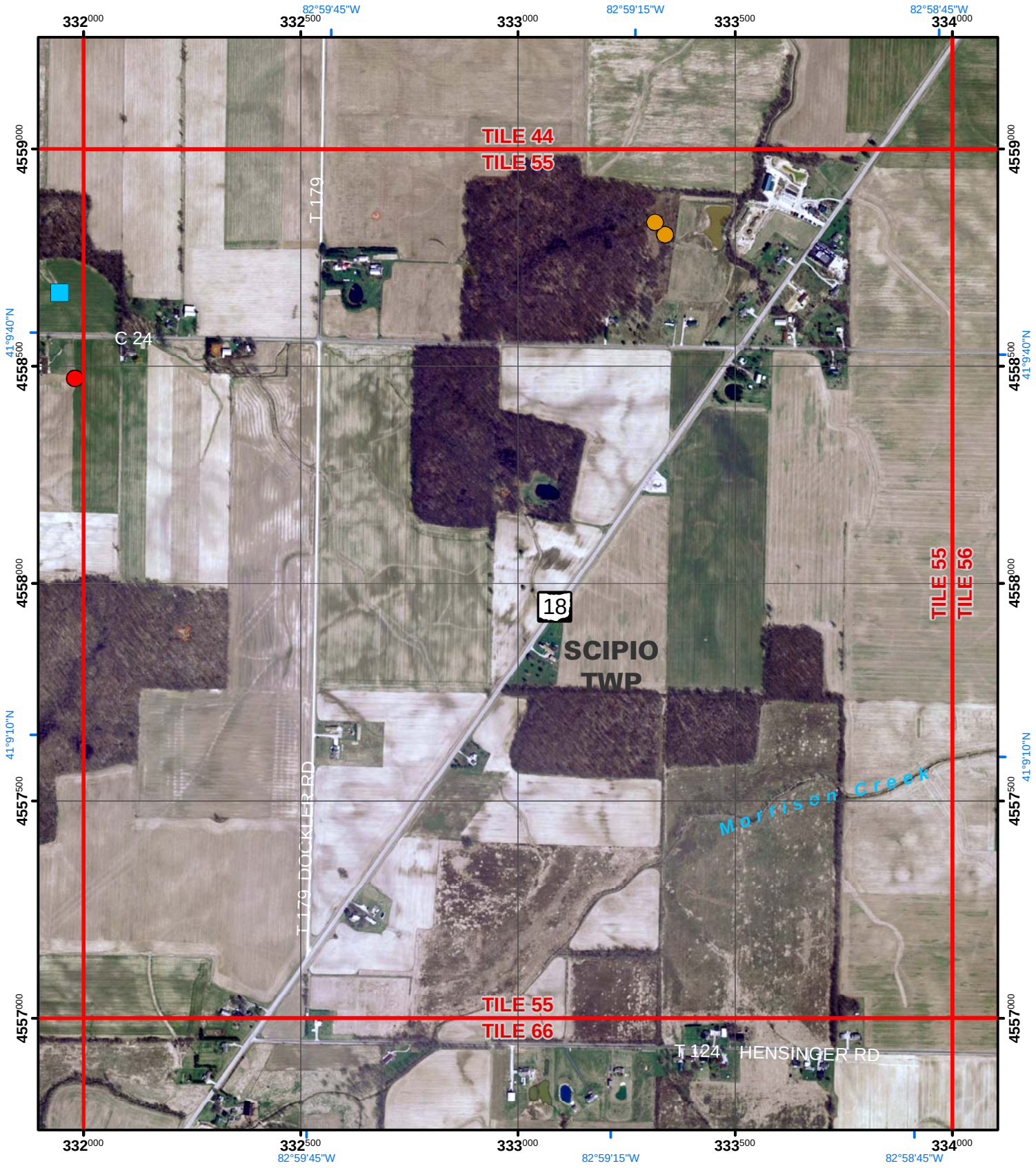
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 55



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 56

U.S. National Grid

100,000-m Square ID: **KE** Grid Zone Designation: **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

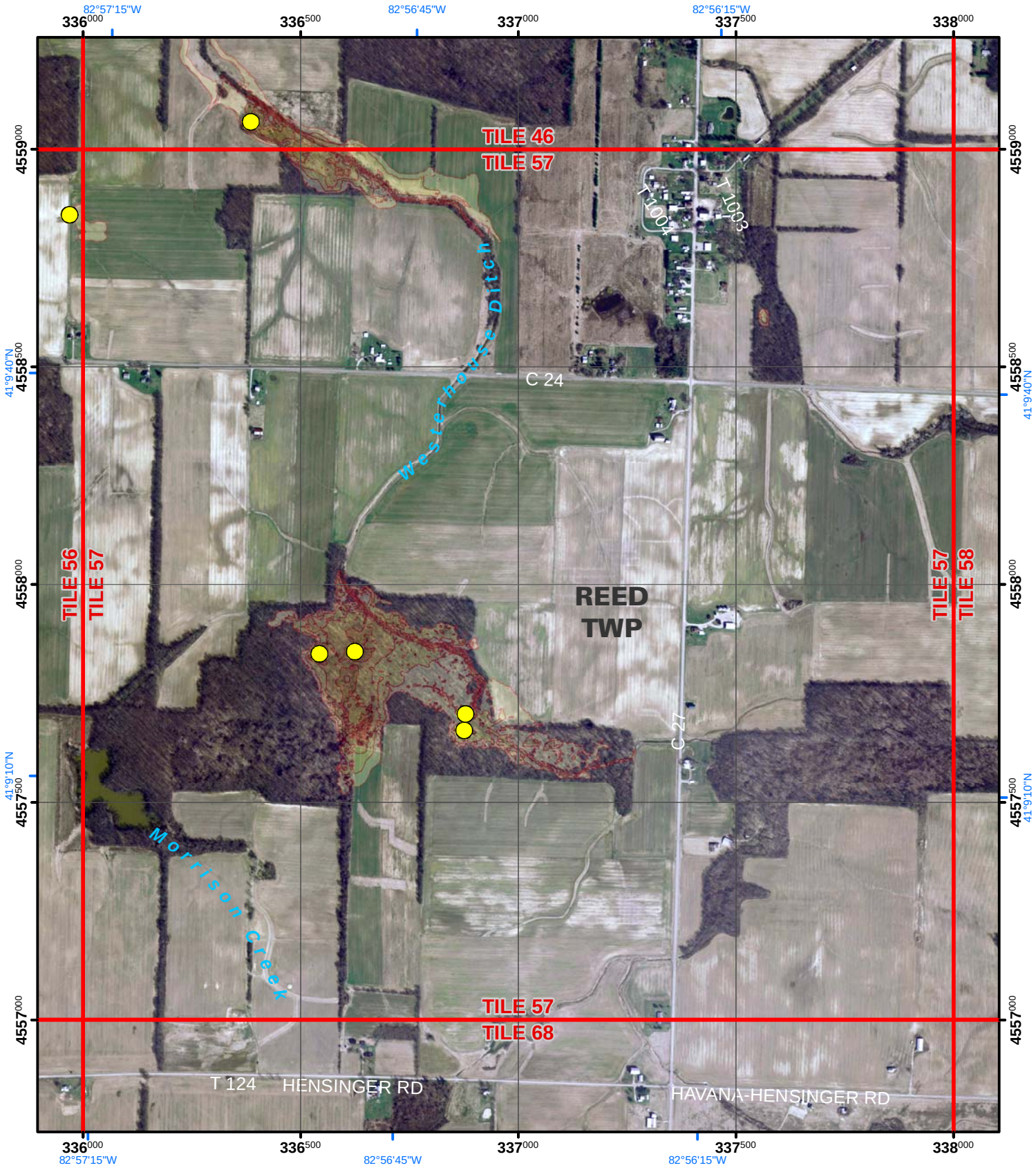
N W E S

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 57



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

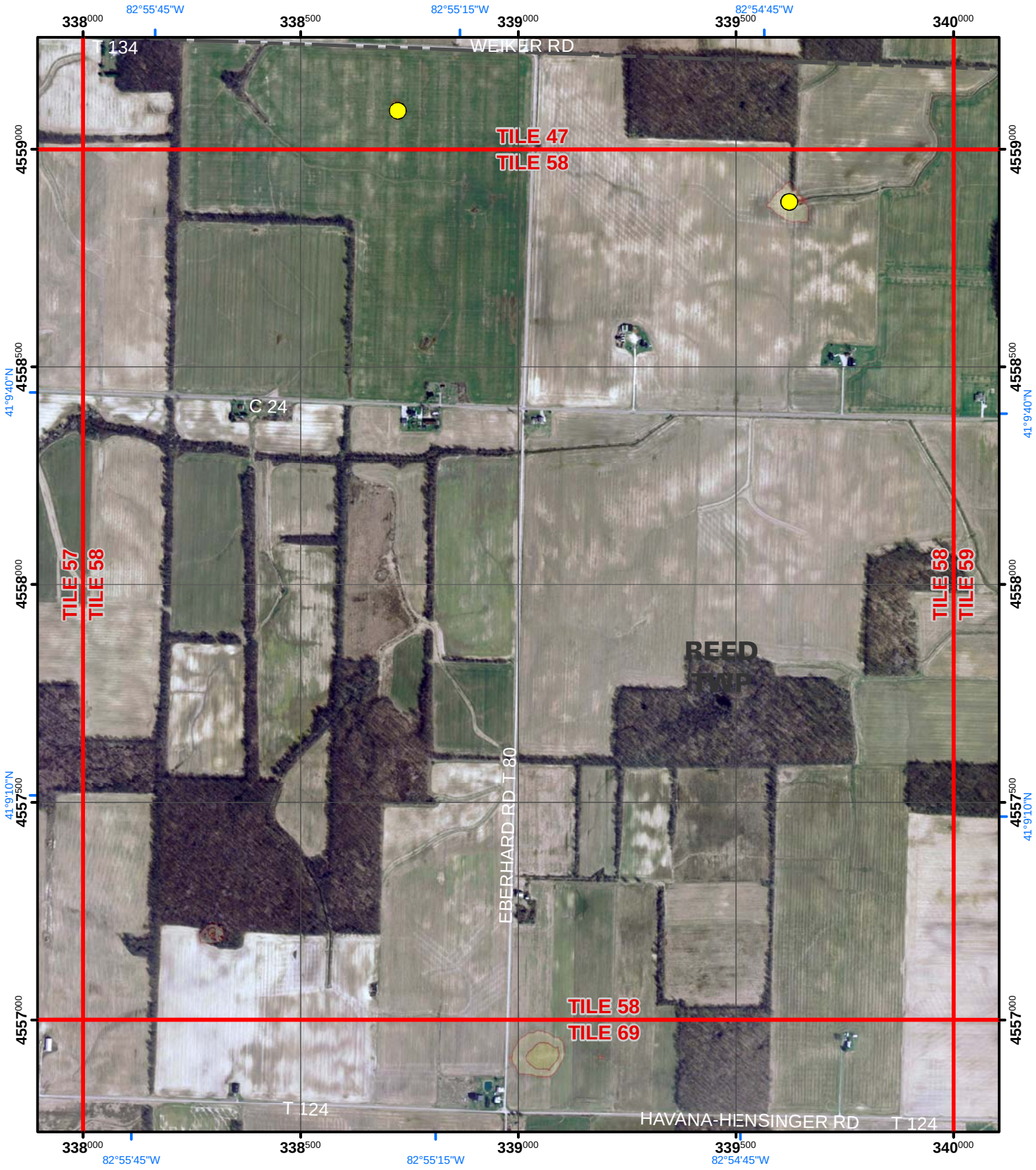
KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 58



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

N W E S

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

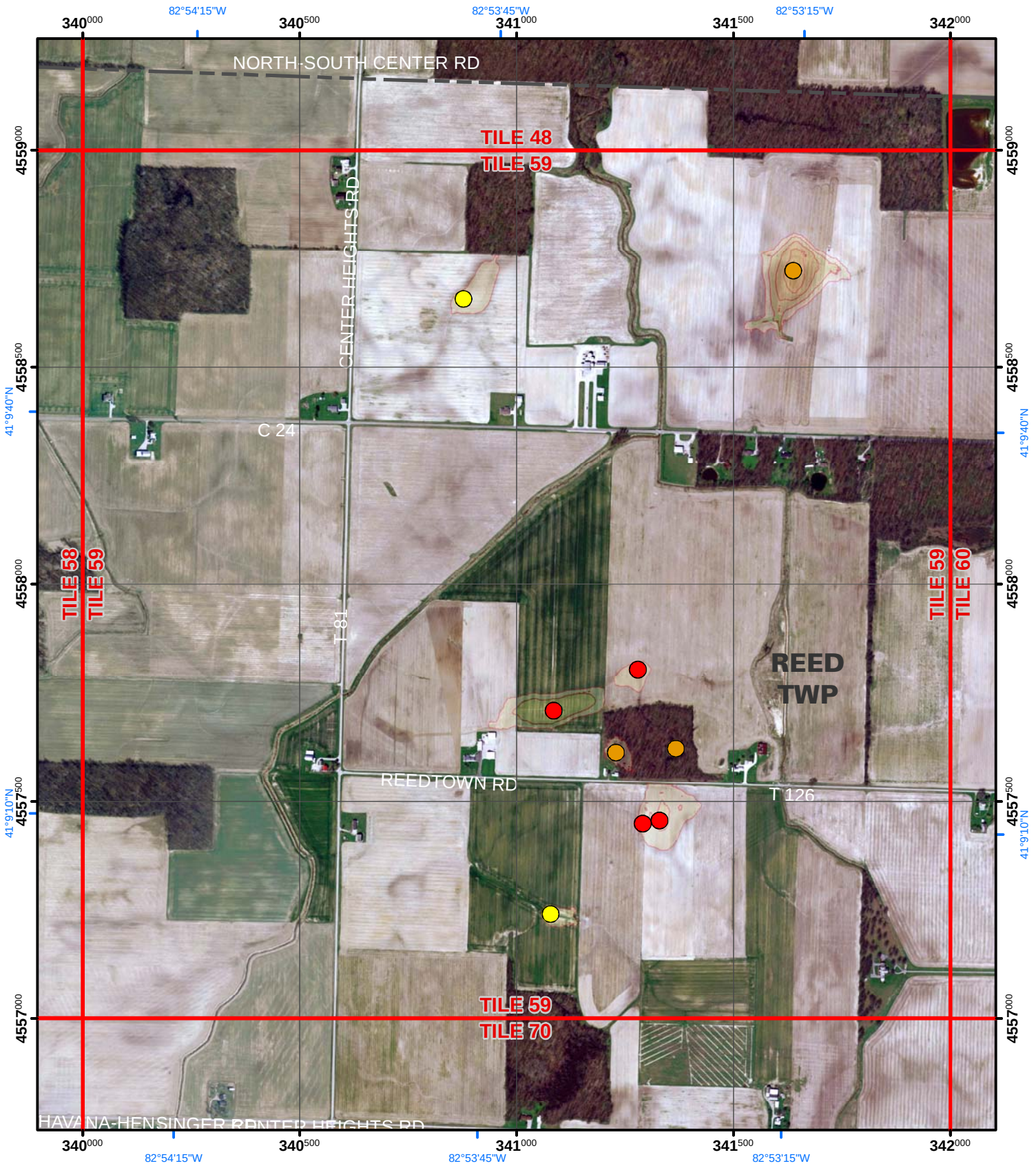
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 59



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

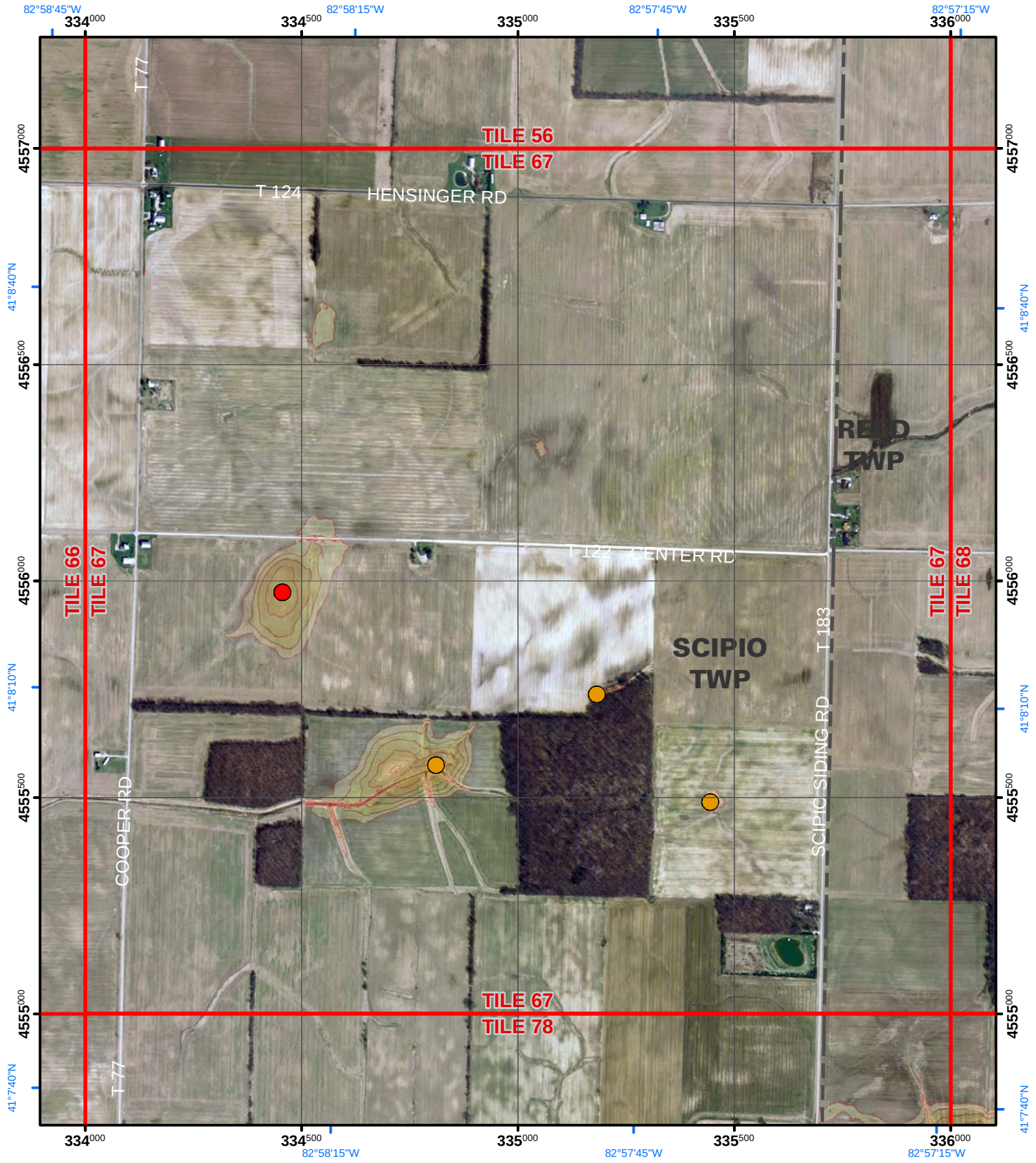
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 67



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

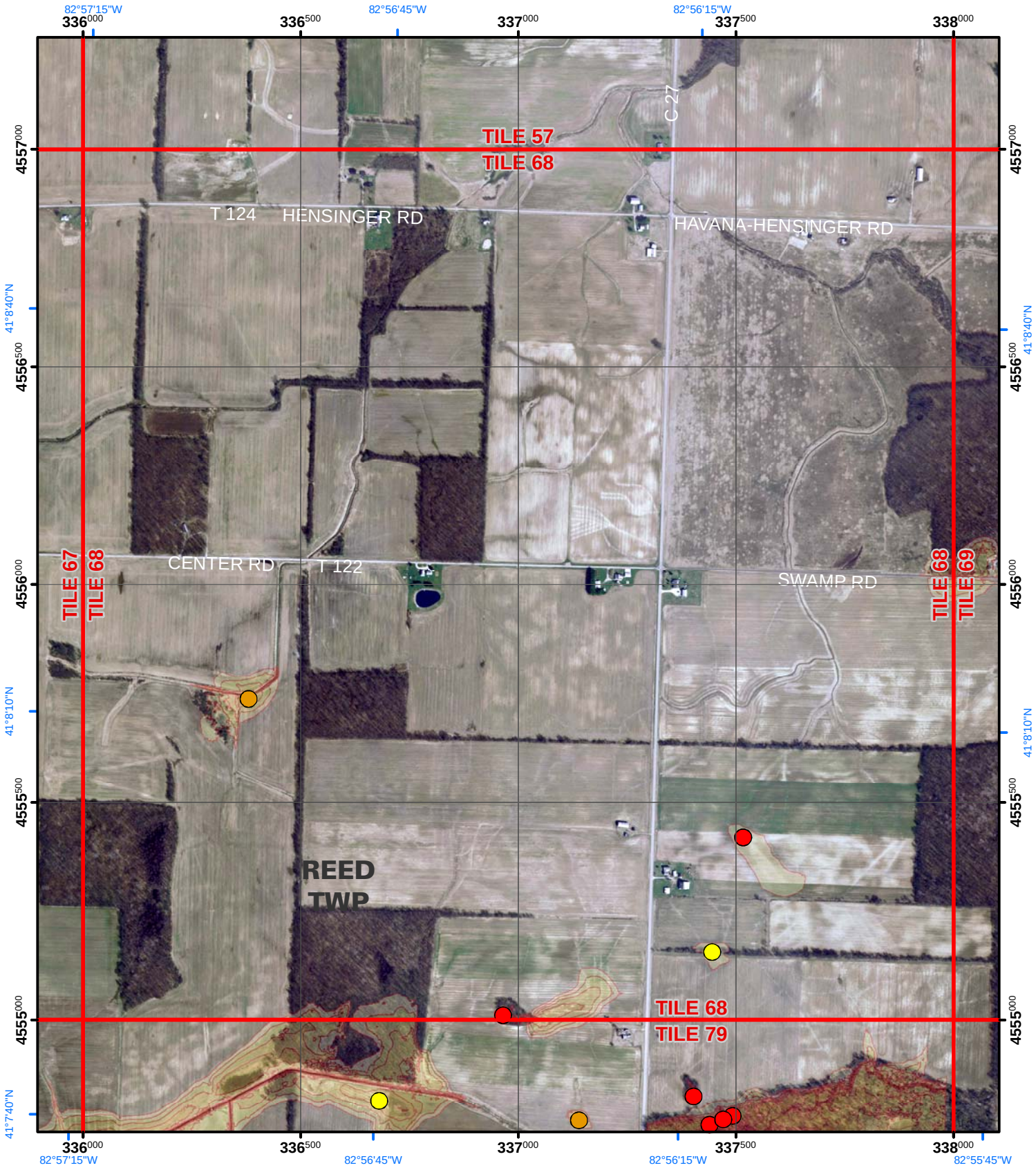
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 68



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

N W E S

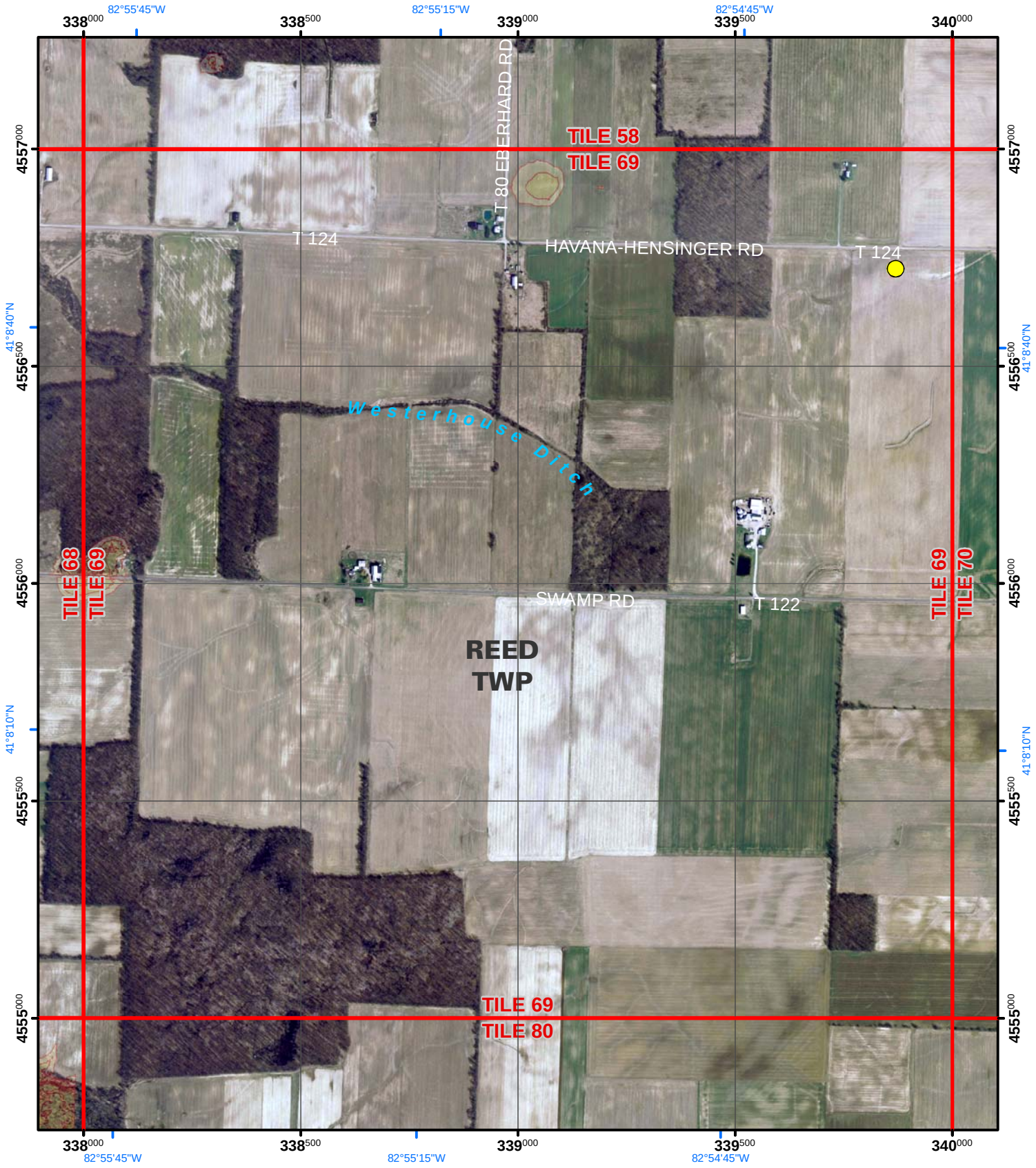
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 69



U.S. National Grid

100,000-m Square ID: **KE**

Grid Zone Designation: **17S**

0 — 0.5 miles

0 — 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

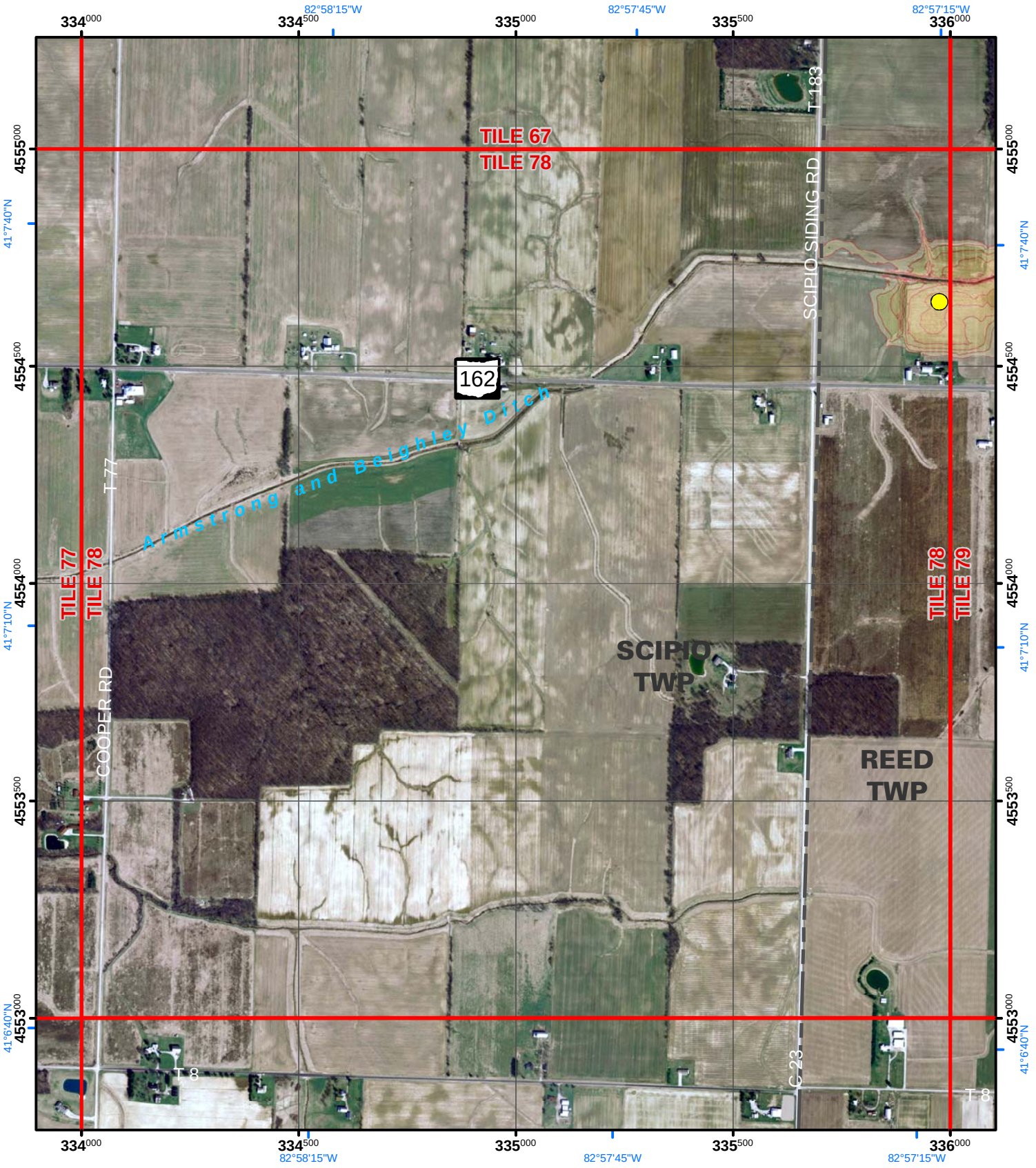
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 78



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

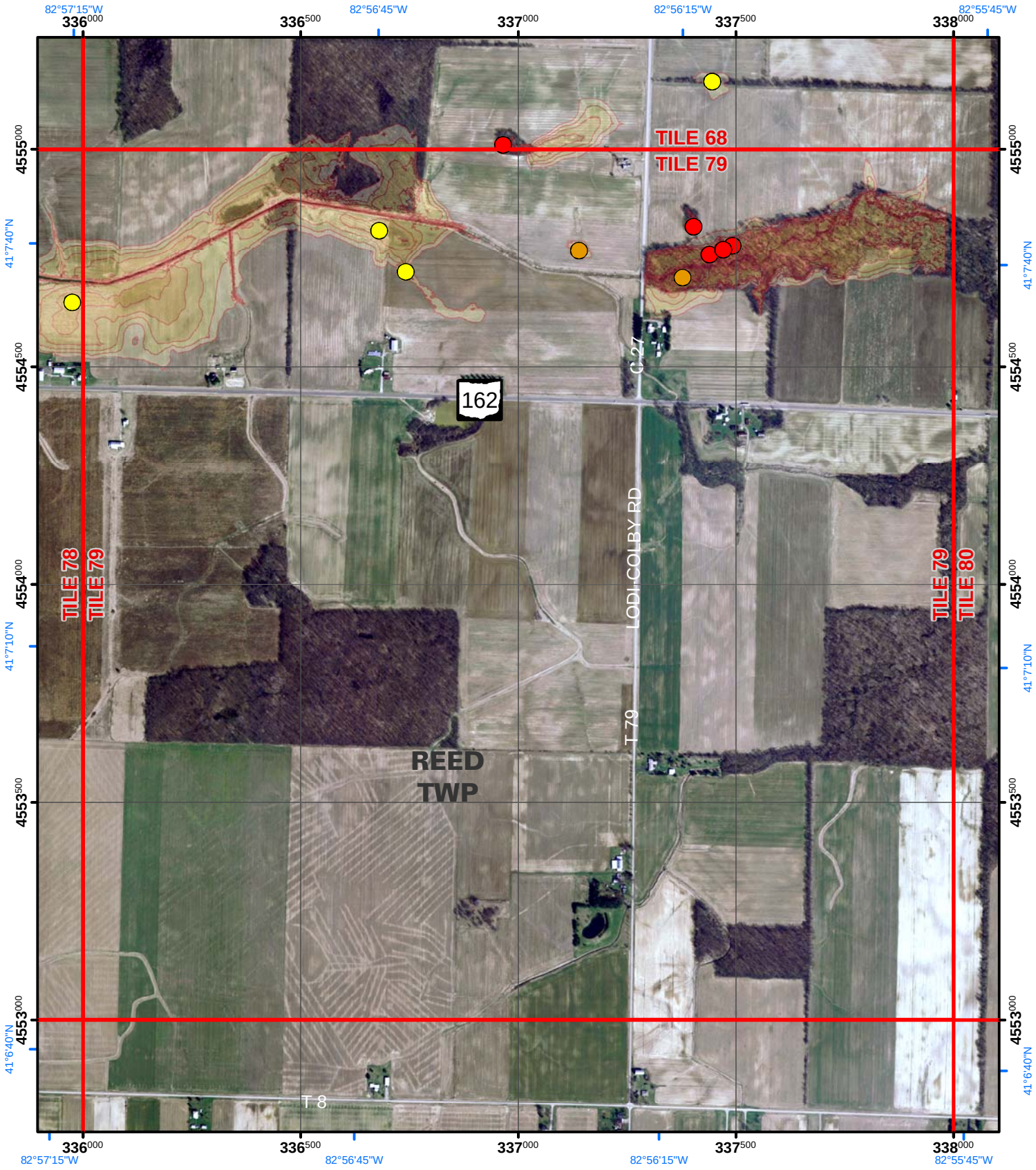
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	

Tile Number: 79



U.S. National Grid

100,000-m Square ID **KE** Grid Zone Designation **17S**

0 0.5 miles

0 1 kilometers

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

KARST FEATURE
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1	5	9
2	6	10
3	7	
4	8	